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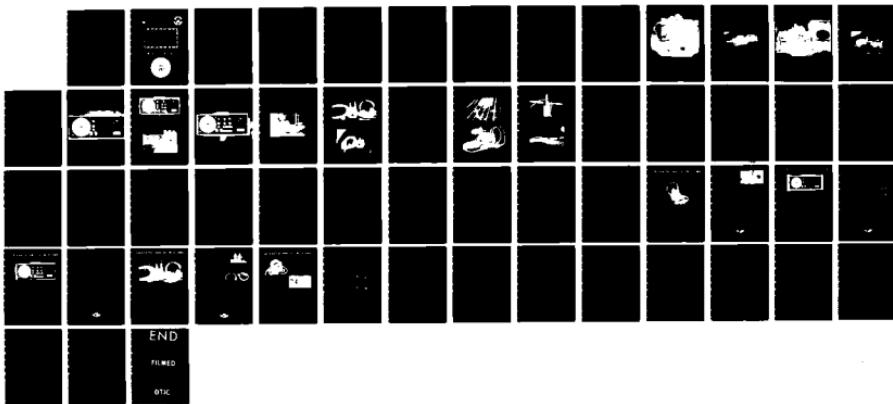
EVALUATION OF THE OCEAN TECHNOLOGY SYSTEM'S MK 1-5
WIRELESS SURFACE UNIT (U) NAVY EXPERIMENTAL DIVING
UNIT PANAMA CITY FL B E REYLE MAY 85 NEDU-6-85

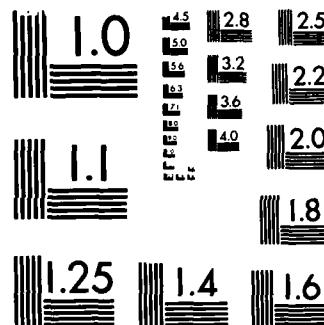
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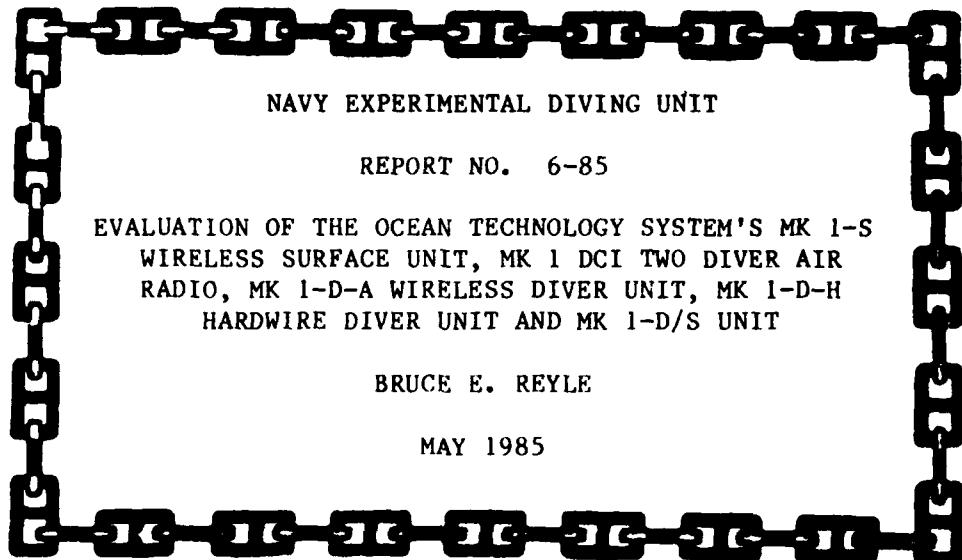




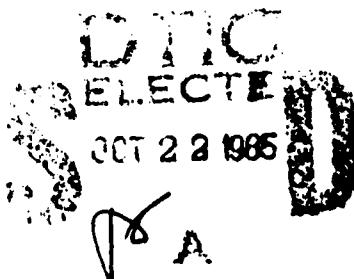
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NAVY EXPERIMENTAL DIVING UNIT



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DEPARTMENT OF THE NAVY
NAVY EXPERIMENTAL DIVING UNIT
PANAMA CITY, FLORIDA 32407

IN REPLY REFER TO:

NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 6-85

EVALUATION OF THE OCEAN TECHNOLOGY SYSTEM'S MK 1-S
WIRELESS SURFACE UNIT, MK 1 DCI TWO DIVER AIR
RADIO, MK 1-D-A WIRELESS DIVER UNIT, MK 1-D-H
HARDWIRE DIVER UNIT AND MK 1-D/S UNIT

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MAY 1985

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) In January 1985, the Ocean Technology System (OTS) MK 1-S wireless surface unit, the MK 1 DCI two-diver air radio, the MK 1-D/S unit, the MK 1-D-A wireless diver unit, and MK 1-D-H hardwire diver unit were tested with the AGA DIVATOR MK II full face mask unit for open circuit self-contained underwater breathing apparatus (SCUBA) gear by the Army Liaison, Navy Experimental Diving Unit (NEDU) at the Special Forces Underwater School, Key West, Florida. The purpose was to determine the system suitability for U.S. Army use with | | |

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open-circuit SCUBA. The OTS was evaluated for intelligibility, reliability and human engineering. The test subjects possessed various levels of experience with wireless or hardwire communication and SCUBA. The conditions under which the equipment was tested varied. Surface air temperatures ranged from 37° to 85°F; water temperatures from 65° to 80°F; and water depths from 8 feet of seawater (FSW) to greater than 60 FSW. The tests were conducted inside a circular 30 foot deep ascent tower, in shallow open bay water, and finally in an open ocean environment. The equipment was evaluated in areas of both high and low noise levels on the surface as well as in water.

The OTS produced an overall intelligibility of 89.24% during manned open water testing using the Modified Rhyme Test (MRT) as the evaluation criteria, with a minimum effective range of 330 yards at 12 FSW and at least 875 yards at depths greater than 60 FSW. Time did not permit testing to distances greater than 875 yards, although it appears that the range of the MK 1-D-A is somewhat greater. Human engineering aspects of the OTS were found to be more than satisfactory, with no material failures encountered during testing. It is interesting to note that whenever the equipment required minor adjustments, these could be effected by the diver in the water (on the surface) and in most cases in less than 5 minutes. The amount of maintenance required on the OTS was minimal.

The OTS MK 1-S wireless surface unit, the MK 1-DCI two-diver air radio, the MK 1-D-A wireless diver unit, the MK 1-D-H hardwire system and the MK 1-D/S are considered to be reliable and effective means of communication for the U.S. Army SCUBA diver.

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Abbreviations

| | |
|---------|---|
| ABS | acrylonitrile butadiene styrenes |
| AMP | ampere(s) |
| cm | centimeters |
| db | decibel(s) |
| °C | degrees centigrade |
| °F | degrees fahrenheit |
| FSW | feet of seawater |
| FFM | full face mask |
| ft | foot (feet) |
| in | inch(es) |
| kg | kilogram(s) |
| km | kilometer |
| kHz | kilohertz |
| LED | light-emitting diode |
| m | meter(s) |
| ma | milliamperes |
| MILSPEC | military specification, e.g. MIL-STD-1472B |
| MRT | modified rhyme test |
| NEDU | Navy Experimental Diving Unit |
| OTS | Ocean Technology System |
| % | percent |
| 1bs | pounds |
| RMS | root mean square |
| SCUBA | self-contained underwater breathing apparatus |
| SD | standard deviation |
| V | volt(s) |
| VOX | voice-activated microphone |
| w | watt(s) |
| yds | yards |

Abstract

In January 1985, the Ocean Technology System (OTS) MK 1-S wireless surface unit, the MK 1 DCI two-diver air radio, the MK 1-D/S unit, the MK 1-D-A wireless diver unit, and MK 1-D-H hardwire diver unit were tested with the AGA DIVATOR MK II full face mask unit for open circuit self-contained underwater breathing apparatus (SCUBA) gear by the Army Liaison, Navy Experimental Diving Unit (NEDU) at the Special Forces Underwater School, Key West, Florida. The purpose was to determine the system suitability for U.S. Army use with open-circuit SCUBA. The OTS was evaluated for intelligibility, reliability and human engineering. The test subjects possessed various levels of experience with wireless or hardwire communication and SCUBA. The conditions under which the equipment was tested varied. Surface air temperatures ranged from 37° to 85°F; water temperatures from 65° to 80°F; and water depths from 8 feet of seawater (FSW) to greater than 60 FSW. The tests were conducted inside a circular 30 foot deep ascent tower, in shallow open bay water, and finally in an open ocean environment. The equipment was evaluated in areas of both high and low noise levels on the surface as well as in water.

The OTS produced an overall intelligibility of 89.24% during manned open water testing using the Modified Rhyme Test (MRT) as the evaluation criteria, with a minimum effective range of 330 yards at 12 FSW and at least 875 yards at depths greater than 60 FSW. Time did not permit testing to distances greater than 875 yards, although it appears that the range of the MK 1-D-A is somewhat greater. Human engineering aspects of the OTS were found to be more than satisfactory, with no material failures encountered during testing. It is interesting to note that whenever the equipment required minor adjustments, these could be effected by the diver in the water (on the surface) and in most cases in less than 5 minutes. The amount of maintenance required on the OTS was minimal.

The OTS MK 1-S wireless surface unit, the MK 1-DCI two-diver air radio, the MK 1-D-A wireless diver unit, the MK 1-D-H hardwire system and the MK 1-D/S are considered to be reliable and effective means of communication for the U.S. Army SCUBA diver.

KEY WORDS: Communicator
Acoustic
Wireless
Through Water

I. INTRODUCTION

In January 1985, the Army Liaison, NEDU, conducted a manned open water evaluation of the OTS MK 1-S wireless surface unit, the MK 1-DCI two diver radio, the MK 1-D-A wireless diver unit, the MK 1-D-H hardwire diver unit, and the MK 1-D/S unit. Testing was accomplished in accordance with NEDU Test Plan 84-46 to determine suitability for U.S. Army use with open circuit SCUBA. The above systems were also evaluated for intelligibility, reliability and human engineering.

The systems are manufactured by OTS, 2610 Croddy Way, Unit H, Santa Ana, California 92704, phone 714-754-7848. The AGA full face mask (FFM), which was tested as an integral part of the communicator, is manufactured by AGA SPIRO AB, S-181 81 Lidingo, Sweden, and is distributed in the United States by OTS and by Viking Diving, 55 Old South Avenue, Stratford, Connecticut 06497.

II. EQUIPMENT DESCRIPTION

The MK 1-D-A wireless diver unit is an acoustic communication system which operates on an amplitude modulated frequency of 31.5 kHz. It can provide diver-to-diver and diver-to-surface communications. It is primarily designed for the free swimming SCUBA diver but can be used as a back-up with umbilical communication systems. It can be used individually or with an unlimited number of units. It is manufactured to be worn with the AGA FFM in both the open-and closed-circuit mode. The unit operates on a rechargeable nickel-cadmium battery pack (or 8-AA alkaline batteries) with a 6 to 7 hour battery life. It has an automatic internal VOX system with adjustable squelch and VOX controls. Its water-activated operation leaves the diver's hands free to perform assigned tasks. The adjustable squelch and VOX controls can be adjusted on the surface by the diver. Power-on is signaled by a red LED on the top of the unit. Housing dimensions are: height 6 in; width 4-3/4 in; depth 2 in; weight (in air) 2-1/2 lbs with batteries, 1-3/4 lbs without batteries. It is operational to depths of 200 FSW. The unit operates in conjunction with the MK 1-S wireless surface unit or the MK 1-D/S (Figure 1). Figure 1a, compares the size of the MK 1-D-A unit to the AGA FFM and the earphone to the left of the exhaust valve. The MK 1-D-A unit mounts on the waist strap of the diver's buoyancy compensator. Figure 1c, shows the tool (flat-tip screwdriver) provided with the unit to make adjustments as needed. In Figure 1d, the unit has been separated into two separate parts. The battery pack is placed inside the lower portion of the unit, displayed on the right side of Figure 1d.

The MK 1-S wireless surface unit is used for communication between divers and topside. It is designed to allow wireless, through-water communications between multi-surface stations and wireless diver units, or between multi-surface stations. Addition of the MK 1-S-HD module also allows "diver on line" communication. The surface tender would then have complete control of the interface between wireless and hardwire divers. The MK 1-S features a remote speaker jack, low battery indicatory, heavy duty panel speaker, record output, squelch, transmit LED, power on (green LED) indicator, diode protection, battery level indicator, external power connection, earphone/microphone jacks, accessory panel, speaker in or out switch, remote

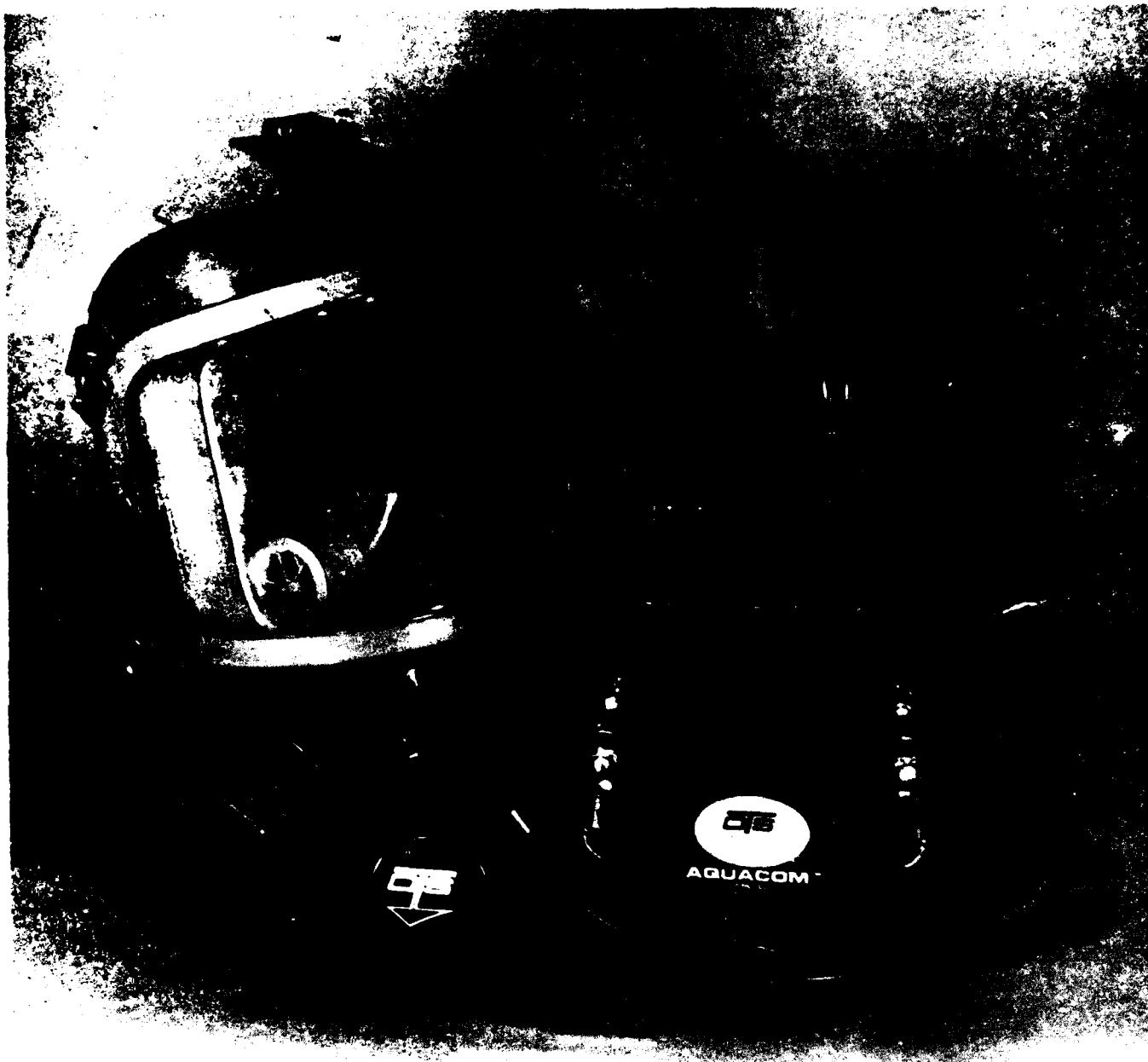


Figure 1a. MK 1-D-A Wireless Dive Unit With MK 11 AGA Full Face Mask

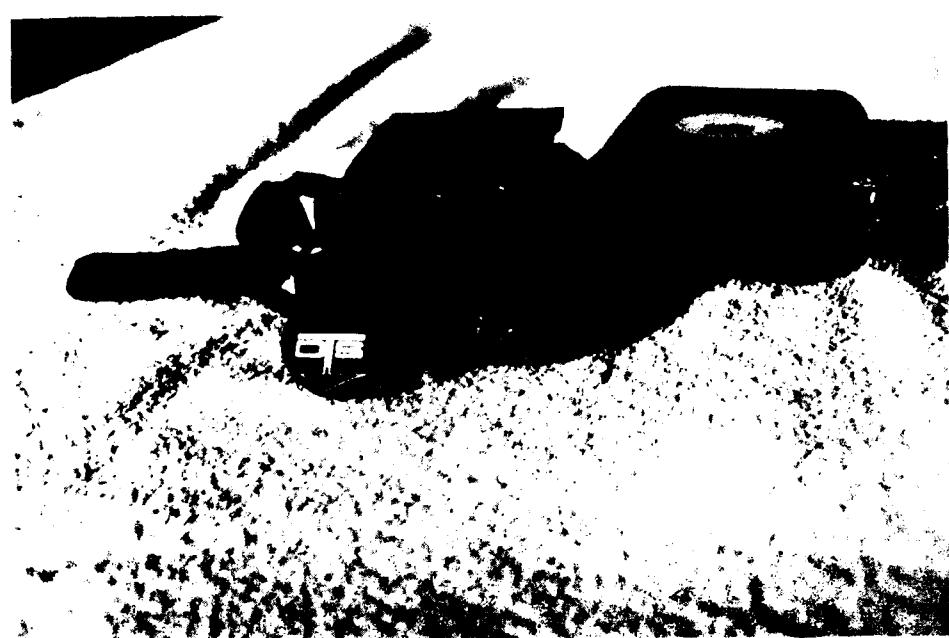


Figure 1b. Top View of MK 1-D-A Unit

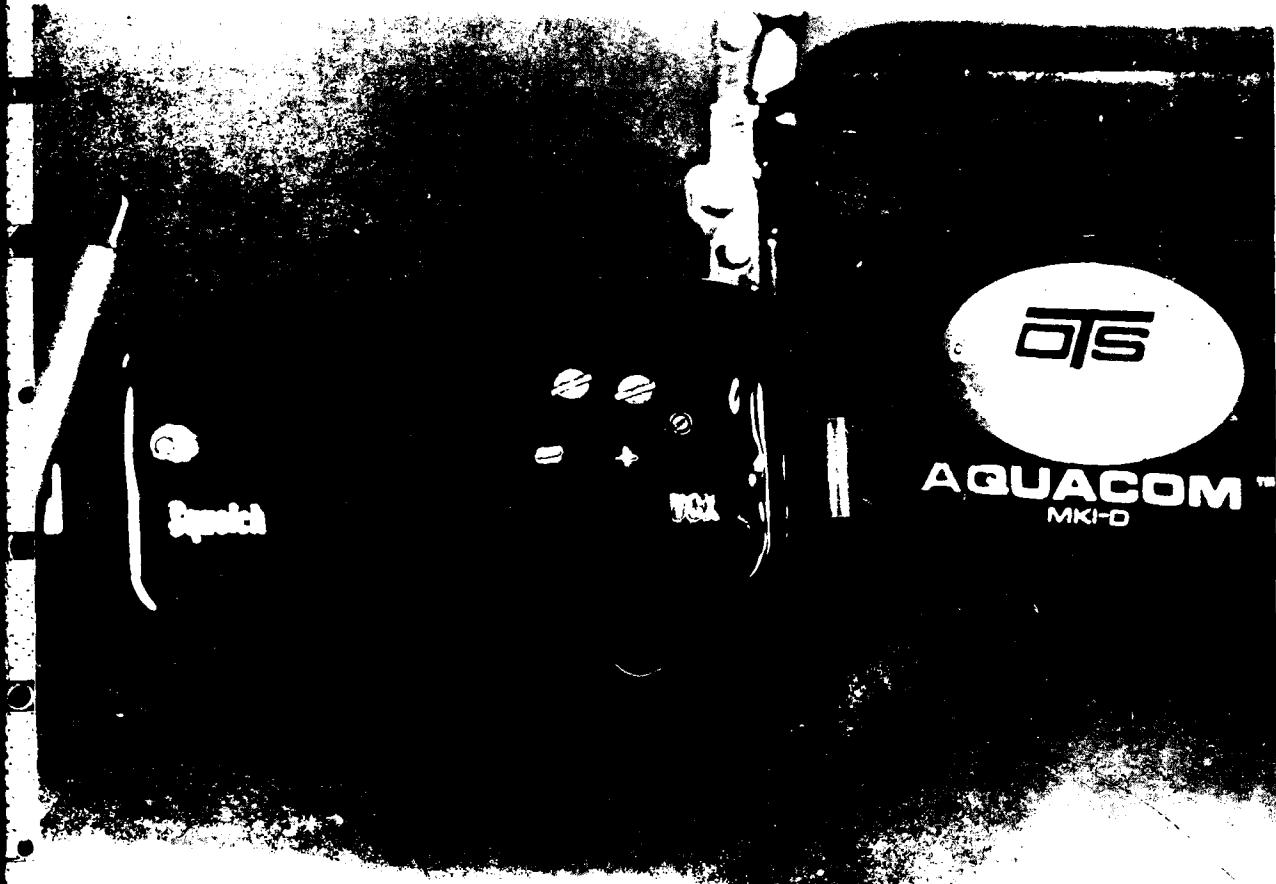


Figure 1c. View of the VOX and Squelch Adjustable Controls on the MK 1-D-A Unit



Figure 1d. View of Battery Pack Used in MK 1-D-A Unit

push-to-talk switch, splashproof ABS plastic cabinet, and a piezoelectric transducer with 75 ft of cable and a BNC connection to mate with the front panel. The MK 1-S also has a 12-V rechargeable battery (Eveready heavy duty Alkaline #528, or Duracell heavy duty Alkaline #1D9150) with a 40 hr battery life, a 12-V battery charger, telex headset with boom microphone, hand held microphone with push-to-talk switch, 8 ohm microphone element or 150 ohm microphone element, and marine underwater connectors (male and female). It operates on 31.5 kHz amplitude modulation and weighs 12-1/2 lbs (15 lbs in shipping carton). Its dimensions are: height 6-5/8 in, width 16-3/8 in, depth 8-3/8 in (Figure 2). In Figure 2b, note the location of the unit, surrounded by six turbine engines similar to the two units in the background.

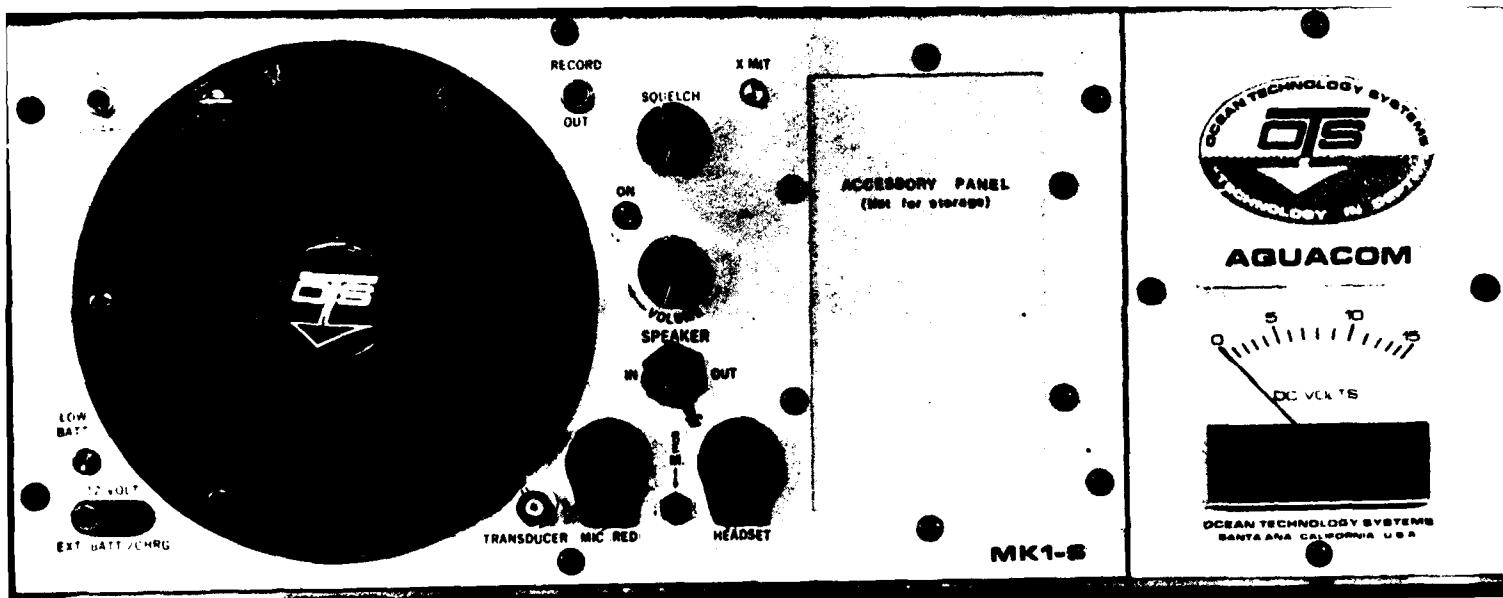
The MK 1-DCI two-diver air radio is a self-contained two-diver air radio that provides two-wire communications between the surface tender and one or two divers. It also has four-wire (round-robin) capabilities using any standard four-wire cable. It features a flashing red LED to signal low battery levels, record output, external speaker jack, panel meter, separate volume controls for tender and divers, on/off switch for the external speaker, external power connection, diode protection, splashproof-ABS plastic cabinet, green LED power-on indicator, and earphone/microphone jacks. It operates on two 6-V batteries (Eveready heavy duty Alkaline #520 or Duracell heavy duty Alkaline #ED9150) or an external power source, has a power output of 8 watts, and has a frequency response of 0.6 to 12 kHz. The battery life is 20 hrs with continuous use. The dimensions of the MK 1-D-DCI are: height 6-5/8 in, width 16-3/8 in, depth 8-3/8 in, and weight 12 lbs (14-1/2 lbs in shipping carton) (Figure 3).

The MK 1-D/S wireless diver unit is essentially the same as the MK 1-D-A unit except the transducer is mounted on a cable that comes in varying lengths (determined by mission requirements) and connected to the power pack via a quick disconnect. It also has a set of headphones with a microphone that corresponds to the earphone on the MK 1-D-A unit. The unit is meant to take the place of the MK 1-DCI if the diver is using the MK 1-D-A and is mounted on the topside supervisor's belt or outer garment in order to free the supervisor's hands for other tasks (Figure 4).

A complete set of manufacturer specifications on the MK 1-D-A, MK 1-S, MK 1-DCI, and MK 1-D/S are provided in APPENDIX A.

The MK 1-D-H hardwire diver unit was a prototype system with, as yet, no fixed manufacturers specifications. This was due to the requirement to test the system for feasibility before establishing specific requirements of the system. The requirements established included:

- a. Secure means of communication between two or more divers participating in a covert operation.
- b. The ability to communicate with the surface, if required, in a completely secure mode.
- c. Lightweight, easy to don and doff, and must not interfere with any part of the Army Special Forces covert mission.
- d. Easy to maintain.



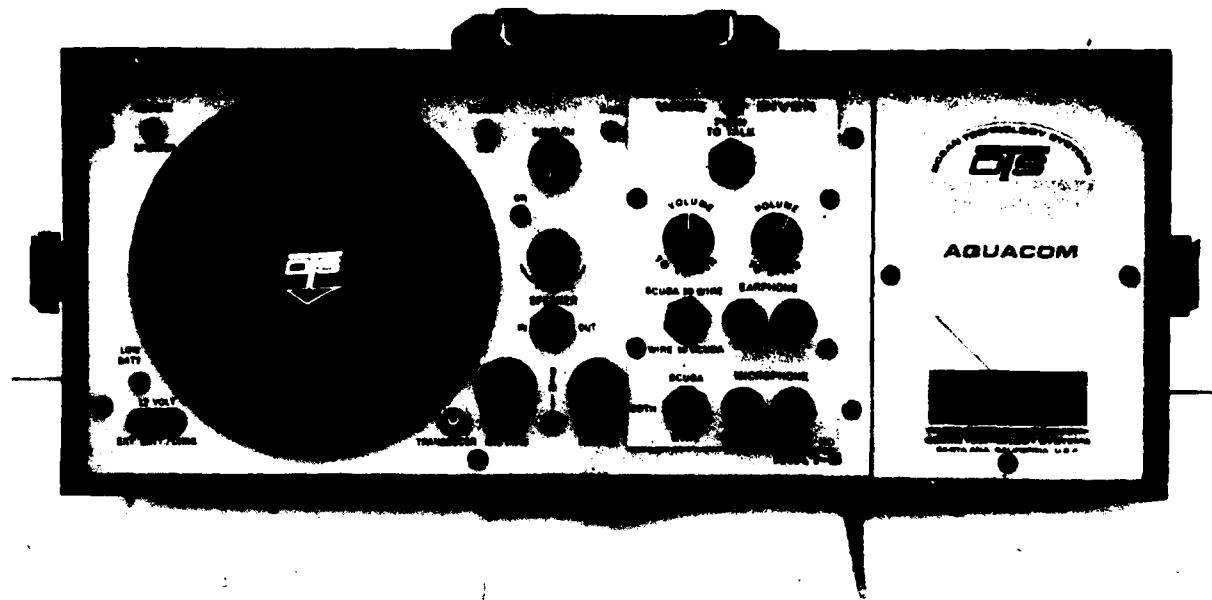


Figure 2b. The MK S Wireless Surface Unit With MK 1-S-HD module



Figure 2c. The MK S With MK 1-S-HD Module in Use

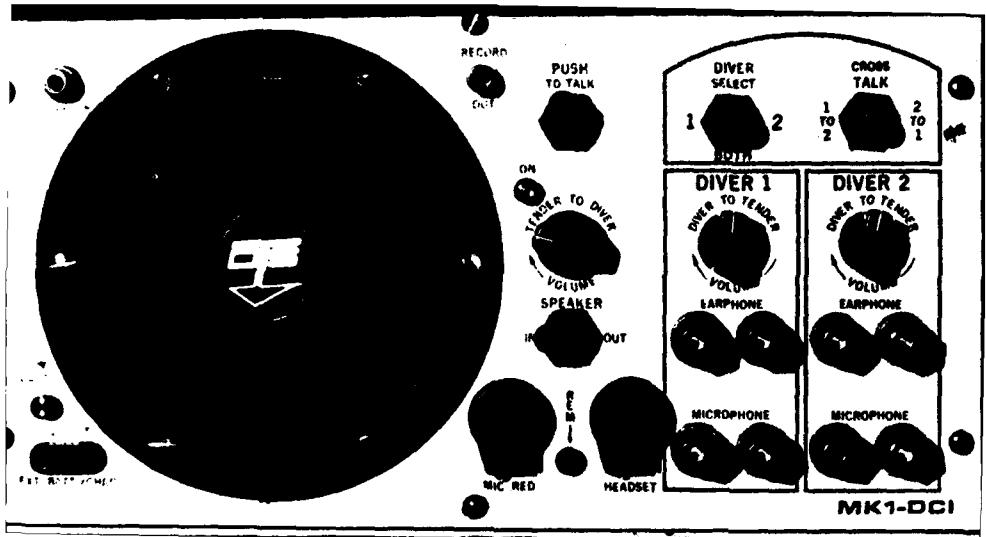




Figure 3b. The MK 1-DC1 Unit in Use (Wireless Mode) in the
30 Ft Ascent Tower



Figure 4a. The MK I-D/S Unit With a 55 Ft Cable and Transducer, Earphones, and Microphone



Figure 4b. The MK I-D/S Unit With a 55 Ft Cable and Transducer

The MK 1-D-H hardwire diver unit has the same dimension specifications as the MK 1-D-A unit. The unit tested had the capability of allowing hard line communication between two or three divers (Figure 5). It is a belt mounted unit with the source of power being worn by only one diver. In Figure 5a, note that the power pack is essentially the same as the MK 1-D-A. In Figure 5d, note the center "ribbed ring" mounted on the left male fitting. Once the connection is made to the female end the "ribbed ring" is tightened down over the female end, preventing separation.

Also included in the manufacturer specifications is data on the AGA MK 11 FFM. A price list is available from OTS upon request.

III. TEST PROCEDURE

A. Intelligibility Tests

1. Intelligibility tests were conducted utilizing one in-water diver pair equipped with MK 1-D-A or MK 1-D-H, one topside tender/listener using the MK 1-DCI, and one topside dive supervisor using the MK 1-S or the MK 1-D/S.

2. Topsid and in-water subjects used the standard NEDU MRT word lists. These word lists provided a reading list and a response sheet for each subject. There were eight tests scored per dive. Nine diver-subjects were used during the evaluation. Six divers were Army Special Forces combat divers from Ft. Bragg, North Carolina, who had no prior experience with in-water communications or use of the AGA FFM. There were also three civilian personnel (Army Liaison, NEDU and two OTS representatives) who participated as test subjects. All subjects rotated through topside diver-reader and diver-listener positions. APPENDICES B1 and B2 provide examples of the NEDU MRT.

3. A minimum of four dive sets were made at each depth to evaluate intelligibility. Different environmental and test locations were also chosen in order to cover as wide a scope of actual "real world" scenarios as possible. The locations included a 30 ft ascent/escape tower, a shallow water open bay, around piers/pilings with constant high surface machinery noise (estimated +100dB), and open water ocean in depths exceeding 60 FSW. Diver-to-diver, diver-to-topsid, topsid-to-diver and topsid-to-topsid communication modes were evaluated. Additionally, unscored infiltration swims were conducted both day and night covering distances from 550 yds to 1650 yds using the MK 1-D-H system.

4. Tests were conducted at depths of 10, 30 and 60 FSW with divers normally 75 to 100 ft apart facing each other. The first test series was conducted in the 30 ft ascent/escape tower to familiarize the subjects with the diving equipment and the MRT list prior to diving in open water at 30 and 60 FSW.

5. Air temperatures during the test dives varied from 37° to 85°F, and water temperatures from 65° to 80°F.

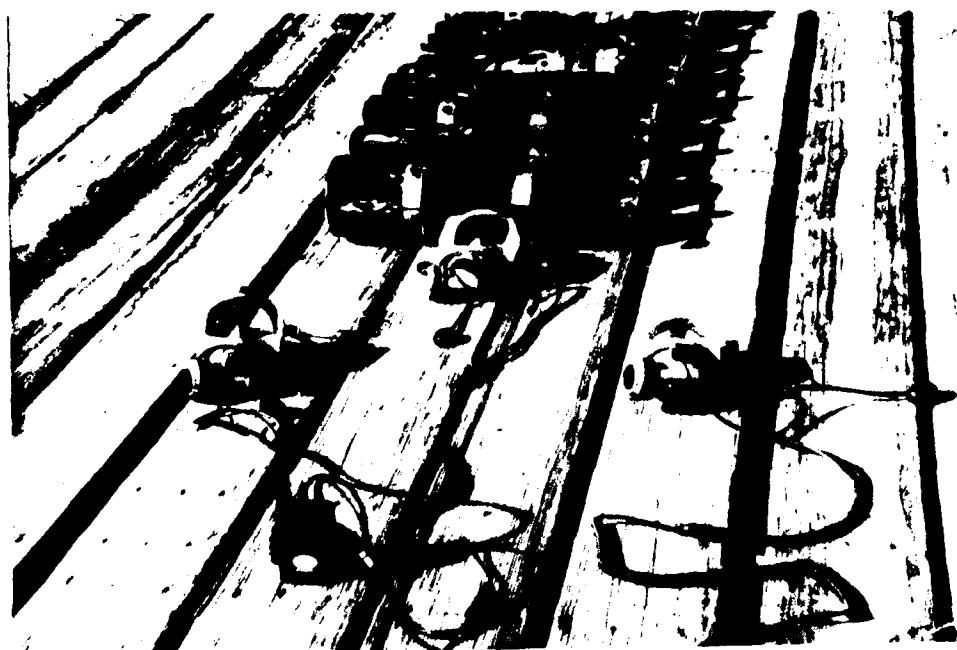


Figure 5a. The MK 1-D-H Three Way Diver Unit

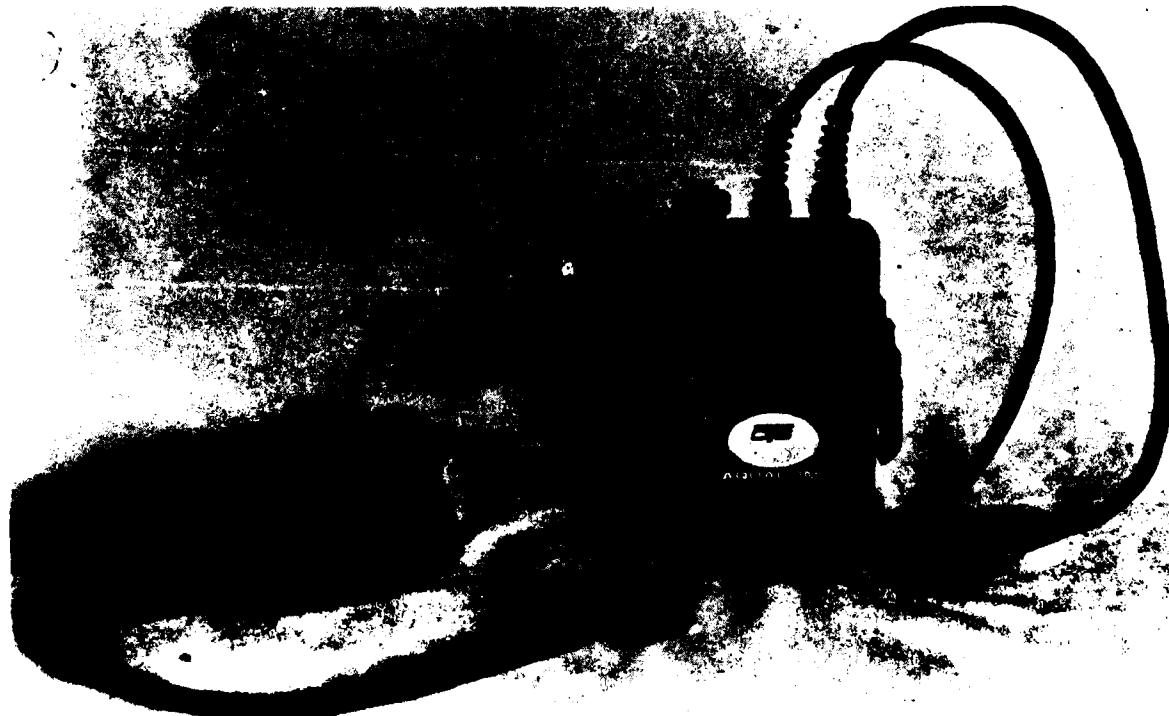


Figure 5b. Front View of the Power Pack Unit of the MK 1-D-H



Figure 5c. Side View of the Power Pack for the MK 1-D-H Unit

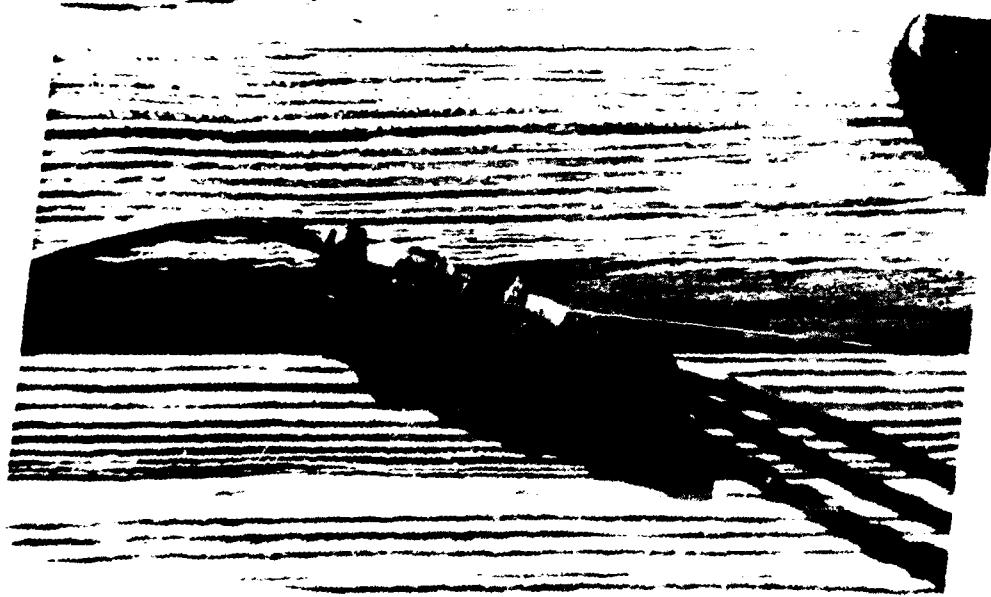


Figure 5d. Close Up of the Male/Female Quick Disconnectors
Used in the MK 1-D-H

6. To determine the percent correct for these tests, the following formula was used (Vancott and Kincaid, 1972):

$$\% \text{ correct} = \frac{2 \times (\text{number right} - \text{number wrong})}{4}$$

B. Range Tests. The same test procedure as the intelligibility test was used except that only one dive pair/topside supervisor was used and tests were conducted in shallow open water (approximately 12 FSW) and open ocean (60 FSW). The maximum range tested was 330 yds for shallow water and approximately 875 yds for open ocean.

C. Human Engineering Evaluation. Following each test dive, each dive pair and supervisor/listener filled out a questionnaire evaluating pre-dive, in-water and post-dive human engineering aspects of the communicators. Formal maintenance lessons were also given to the Army divers at the request of the unit OIC. APPENDIX C provides a copy of the evaluation form used.

IV. RESULTS AND DISCUSSION

A. Intelligibility Tests. Since the basic purpose of how well a communication system operates is intelligibility, an index of measuring and assessing effectiveness of any voice communication system must be objectively chosen. The Griffiths (1967) version of the previously developed MRT (House, et al, 1965) was employed for this purpose. It was chosen because of its ease of administration and scoring, its stability with respect to learning effects, and because it requires minimal listener training. Gelfand, et al, 1978, report the successful use of the test on a 1600 FSW dive. Although the MRT is not phonetically balanced to represent everyday speech, it is efficient and useful because it requires perception of consonantal sounds (sounds that are difficult to transmit successfully) and are thus more important than vowels to intelligibility. Finally, it was also chosen because it was recommended by the medical staff at NEDU as the only "currently in use" valid MRT.

The MRT consists of 50 sets of words, with five words in each set (see APPENDIX B1 and B2). In a typical test, a reader reads one specific word from each set in the following way: "Number 1, the word is badge, the word is badge. Pause; Number 2, the word is log, the word is log", etc. The reader was instructed to pause at least three seconds between each phrase. The listener who held a response sheet with the same 50 sets of words, marked the word that he "heard" from each set by the reader. Eight different reading lists were randomly employed during the course of the evaluation and six different response lists. This was to insure that the test subjects did not "memorize" the lists as the test progressed into its later stages. The order of the words within each set on the various response word lists were different to counterbalance the tendency of listeners to mark the first word in a set when in doubt or when guessing. Once a word list was completed, the percent correct was calculated using the following formula (Van Cott and Kincaid, 1972):

$$\% \text{ correct} = \frac{2 \times (\text{number right} - \text{number wrong})}{4}$$

The tests were all scored by the NEDU task leader to avoid any alterations on the test.

The number of wrong answers was divided by four and subtracted from the number of right answers. The resultant was then multiplied by two. This manipulation was essentially a correction factor for guessing.

The intelligibility criteria for military voice communications systems is set forth in MIL-STD-1472B (see references). This military standard sets the minimum acceptable intelligibility when using the MRT as the evaluation criteria as 75% correct.

Tables 1 through 5 present mean intelligibility score for diver-to-diver, diver-to-topside, topside-to-diver, topside-to-topside, respectively. A minimum of four tests were conducted in each operational mode. Scores ranged from a low mean score of 85.11% correct to a high mean of 94% correct. The overall average, based on a total of 126 tests in all four modes, was 89.24% (excluding range tests). The data tabulated in Tables 1 through 5 is in chronological order for each mode. A thorough analysis will reveal that in every mode at each depth, the percent correct generally increased as the number of dives progressed.

Testing took place using a total of nine different diver/topside subjects over a two week period. Dives were conducted in daylight and at night in a variety of environmental conditions and at different locations in and around the Special Forces Underwater Operations School, Key West, Florida. Any VOX-operated communicators of this type have a pronounced learning curve associated with effective use of the equipment. The six Army Special Forces divers had no previous experience using the AGA FFM or in-water communication systems. Two of the six Army divers had just graduated from the Special Forces Diving School and were thus considered to be inexperienced divers. Near the end of the evaluation the test subjects were much more proficient and at ease with the AGA FFM and OTS equipment. Use of a "throw-away" word to activate the VOX (such as the word "ah") became second nature. Also, the test subjects' awareness of the need not to pause in the middle of a sentence, since this shut off the transmitter if the pause lasted more than one second, was much increased and intelligibility scores improved accordingly. The two Army SF divers who were "inexperienced divers" scored the lowest scores on their first one or two dives of the day or when going from one location to another. If you throw out the inexperienced divers' first scores, the Table 1 percent correct increases from 87.78% to 89.29%. This is especially important since it indicates that the low initial scores recorded were due to the divers' apprehension in the water and lack of familiarization with the equipment rather than actual AGA and OTS limitations.

It is significant that the tests done at 60 FSW did not show any substantial degradation in intelligibility when compared to the shallower tests. In many communicators where intelligibility is marginal, increased air density and water depths reduces performance. This was not the case with the OTS.

TABLE 1
DIVER-TO-DIVER

A. 30 FT TOWER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 68.8 |
| | 2 | 66.4 |
| 2 | 3 | 80.2 |
| | 4 | 95.2 |
| 3 | 5 | 92.8 |
| | 6 | 100 |
| 4 | 7 | 73.6 |
| | 8 | 92.8 |
| 5 | 9 | 95.2 |
| | 10 | 90.4 |

Mean score: 85.5% (SD = 12.2)

NOTE: Diver #1 is same as #10, #2 is same as #9, #3 is same as #8, #4 is same as #7

B. OPEN BAY - SHALLOW WATER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 80.2 |
| | 2 | 85.6 |
| 2 | 3 | 90.4 |
| | 4 | 95.2 |
| 3 | 5 | 97.6 |
| | 6 | 90.4 |
| 4 | 7 | 73.6 |
| | 8 | 92.8 |
| 5 | 9 | 100 |
| | 10 | 90.4 |
| 6 | 11 | 90.4 |
| | 12 | 92.8 |

Mean score: 89.95% (SD = 7.3)

TABLE 1 (continued)

DIVER-TO-DIVER

C. OPEN OCEAN - 60 FSW

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 92.8 |
| | 2 | 85.6 |
| 2 | 3 | 85.6 |
| | 4 | 68.8 |
| 3 | 5 | 73.6 |
| | 6 | 100 |
| 4 | 7 | 97.6 |
| | 8 | 90.4 |
| 5 | 9 | 92.8 |
| | 10 | 90.4 |
| 6 | 11 | 88 |
| | 12 | 85.6 |

Mean score: 87.9% (SD = 9.2)

D. OVERALL DIVER-TO-DIVER INTELLIGIBILITY SCORE: 87.78%

Overall SD = 9.6

TABLE 2
DIVER-TO-TOPSIDE

A. 30 FT TOWER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 85.6 |
| | 2 | 80.2 |
| 2 | 3 | 90.4 |
| | 4 | 95.2 |
| 3 | 5 | 97.6 |
| | 6 | 88 |
| 4 | 7 | 88 |
| | 8 | 90.4 |
| 5 | 9 | 85.6 |
| | 10 | 80.2 |

Mean score: 88.12% (SD = 5.6)

B. OPEN BAY - SHALLOW WATER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 92.8 |
| | 2 | 100 |
| 2 | 3 | 80.8 |
| | 4 | 97.6 |
| 3 | 5 | 100 |
| | 6 | 85.6 |
| 4 | 7 | 88 |
| | 8 | 83.2 |
| 5 | 9 | 92.8 |
| | 10 | 90.4 |
| 6 | 11 | 92.8 |
| | 12 | 97.6 |

Mean score: 91.8% (SD = 6.4)

TABLE 2 (continued)

DIVER-TO-TOPSIDE

C. OPEN WATER - 60 FSW

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 83.2 |
| | 2 | 92.8 |
| 2 | 3 | 90.4 |
| | 4 | 92.8 |
| 3 | 5 | 90.4 |
| | 6 | 88 |
| 4 | 7 | 97.6 |
| | 8 | 100 |
| 5 | 9 | 90.4 |
| | 10 | 85.6 |
| 6 | 11 | 88 |
| | 12 | 80.2 |

Mean score: 89.95% (SD = 5.58)

D. OVERALL DIVER-TO-TOPSIDE INTELLIGIBILITY SCORE: 89.95%

Overall SD = 5.86

TABLE 3
TOPSIDE-TO-DIVER

A. 30 FT TOWER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 85.6 |
| | 2 | 71.2 |
| 2 | 3 | 97.6 |
| | 4 | 90.4 |
| 3 | 5 | 78.2 |
| | 6 | 88 |
| 4 | 7 | 83.2 |
| | 8 | 100 |
| 5 | 9 | 97.6 |
| | 10 | 90.4 |

Mean score: 88.2% (SD = 9.1)

B. OPEN BAY - SHALLOW WATER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 71.2 |
| | 2 | 61.6 |
| 2 | 3 | 87.2 |
| | 4 | 92.8 |
| 3 | 5 | 83.2 |
| | 6 | 83.2 |
| 4 | 7 | 88 |
| | 8 | 92.8 |
| 5 | 9 | 90.4 |
| | 10 | 100 |
| 6 | 11 | 85.6 |
| | 12 | 97.6 |

Mean score: 82.8% (SD = 15.54)

TABLE 3 (continued)

TOPSIDE-TO-DIVER

C. OPEN WATER - 60 FSW

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 71.2 |
| | 2 | 97.6 |
| 2 | 3 | 90.4 |
| | 4 | 78.2 |
| 3 | 5 | 85.6 |
| | 6 | 90.4 |
| 4 | 7 | 68.8 |
| | 8 | 95.2 |
| 5 | 9 | 92.8 |
| | 10 | 66.4 |
| 6 | 11 | 80.2 |
| | 12 | 95.2 |

Mean score: 84.33% (SD = 11.07)

D. OVERALL TOPSIDE-TO-DIVER INTELLIGIBILITY SCORE: 85.11%

Overall SD = 11.9

TABLE 4
TOPSIDE-TO-TOPSIDE

A. 30 FT TOWER: No data was collected at the 30 ft tower due to proximity of topside units.

B. OPEN BAY - SHALLOW WATER

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 92.8 |
| | 2 | 88 |
| 2 | 3 | 97.6 |
| | 4 | 97.6 |
| 3 | 5 | 90.4 |
| | 6 | 95.2 |
| 4 | 7 | 90.4 |
| | 8 | 100 |
| 5 | 9 | 90.4 |
| | 10 | 97.6 |
| 6 | 11 | 92.8 |
| | 12 | 95.2 |

Mean score: 94% (SD = 3.76)

C. OPEN WATER - 60 FSW

| Dive No. | Diver | Score (% Correct) |
|----------|-------|-------------------|
| 1 | 1 | 95.2 |
| | 2 | 90.4 |
| 2 | 3 | 90.4 |
| | 4 | 97.6 |
| 3 | 5 | 100 |
| | 6 | 92.8 |
| 4 | 7 | 97.6 |
| | 8 | 95.2 |
| 5 | 9 | 92.8 |
| | 10 | 97.6 |
| 6 | 11 | 90.4 |
| | 12 | 90.4 |

Mean score: 94.2% (SD = 3.46)

TABLE 4 (continued)

TOPSIDE-TO-TOPSIDE

D. OVERALL TOPSIDE-TO-TOPSIDE INTELLIGIBILITY SCORE: 94.1%

Overall SD = 3.61

TABLE 5
OVERALL MEAN INTELLIGIBILITY SCORE FOR ALL
OTS COMMUNICATION EQUIPMENT EVALUATED

| | Score (% Correct) |
|---------|-------------------|
| Table 1 | 87.9 |
| Table 2 | 89.95 |
| Table 3 | 85.11 |
| Table 4 | 94 |

NOTES:

- (1) All dives are listed in chronological order with the first test series conducted in the 30 ft tower, the second series in open bay - shallow water, the rest done in open water at 60 FSW.
- (2) Dropping the first two scores from Table 1 (30 ft tower) improves the mean score from 87.78% to 89.29% for Table 1 and the SD from 9.6 to 8.4. It also changes the overall performance of the OTS' mean score from 89.24% to 89.58% and the SD from 3.74 to 3.63.
- (3) A total of 126 tests were conducted.

As with any acoustic communicator, care had to be taken to insure that physical barriers did not exist between diver-subjects, diver-to-topside, and topside-to-topside so that the transmitted signals were not reflected back or interrupted prior to reaching their target. Care was exercised during the shallow bay diving tests to insure that there were no organic barriers (e.g., sea weed) or physical objects/structures between the test subjects to interfere with the signal. In addition, all tests were conducted with the diver-subjects facing each other since the diver's body would significantly reduce the transmitted signal if placed between the transducer mounted on the weight belt and the target. It was observed that the signal would be "masked" or "disrupted" by the diver's exhaust bubbles if the divers were not facing each other or if the transducer was placed under the buoyancy compensator. The air in the compensator would distort and reflect the acoustic signal from the transducer and reduce but not totally prevent the ability to communicate. Finally, although not experienced, the transducer suspended from the surface unit must be below any thermocline between the diver-subject and surface. Thermoclines will reflect or attenuate the transmitted acoustic signal. All of these limitations in the equipments performance are inherent in any acoustic communicator system and are not a function of the OTS design.

B. Range Tests. The OTS MK 1-D-A has an advertised range of 100 ft with high background noise to 440 yds in quiet conditions. Range testing was performed in two locations: open bay shallow depths and open ocean at a depth of 60 FSW. In the open bay scenario the diver was placed in a stationary location on the bottom (approximately 12 FSW) and the topside listener moved away from the diver until communications with each unit was not intelligible; the distance covered was estimated to be between 300 to 350 yds. It must be noted that the bottom conditions were considered irregular with intermittent areas of coral and seaweed. The surface condition was slightly choppy. A score of 85% correct was recorded. In open ocean water at 60 FSW the test procedure for shallow water bay diving was repeated (with a safety boat remaining above the diver). The range was estimated to be between 750 and 900 yds. The intelligibility score recorded was 86.7%. Time did not allow further intelligibility tests nor range tests, however, indications during the open ocean range test point out that the range of approximately 875 yds can be exceeded depending upon water conditions. Additionally, organic life and inorganic objects will decrease the range or totally interrupt the signal if it is between the diver unit and topside unit. This is not a unique limitation of the OTS but is inherent in any acoustic wireless communicator system.

C. Human Engineering. APPENDIX C illustrates the form used to evaluate human engineering parameters for the AGA MK II and OTS MK 1-D-A or MK 1-D-H. In all categories, the AGA MK II, OTS MK 1-D-A, and MK 1-D-H was found to be extremely comfortable, easy to don and doff with few problems experienced by the diver-subjects in water. Evaluation forms revealed that most divers readjusted the earphones once or twice in water to improve on intelligibility during the MRT and for regular communication. The reason for this was solely related to the lack of familiarization with using the equipment. Also revealed was the fact that the divers preferred to wear the transducer on the weight belt or waist strap (on the side) of the buoyancy compensator. This facilitated donning and doffing the system in the water. One comment by a SF diver of particular interest was made about ease in maintenance and

adjustments to the squelch and VOX controls. "I was surprised at the small amount of time it took me to make the adjustments on the surface, the tool provided with the unit is a nice touch. Also, it is surprising just how little maintenance the DK 1-D-A unit requires."

A unique feature of the OTS MK 1-D-A and DK 1-D-H is that, while it turns itself on automatically upon entry into the water, the unit shuts off if any connector between the MK 1-D-A or DK 1-D-H and AGA MK 11 FFM is broken. This allows the MK 1-D-A or DK 1-D-H to be disconnected from the AGA FFM in the water without electrolytic corrosion occurring at the connector pins. Additionally, if the o-ring seal between connectors is damaged or missing upon achieving depths greater than 10 ft the unit emits a sound heard by the diver similar to feedback in a loudspeaker system and then shuts down automatically, with no damage to the system. Because spare o-rings are part of the MK 1-D-A and MK 1-D-H unit, repairs can be made by the diver on the surface, usually in less than 3 minutes.

The MK 1-DCI, MK 1-S, and MK 1-D/S units performed well and proved to be resistant to splash from wave spray, divers entering the water, and rain. The combination of loudspeaker and headset/boom-mike provided excellent communication between the diver-subjects and topside subjects/supervisors while allowing other topside parties to monitor the conversation via the loudspeaker. The MK 1-D/S unit provided a mobile topside capability for the dive supervisor whenever the loudspeaker was not required and provided communications quality similar to the MK 1-DCI and MK 1-S.

All transducers, cables and connectors were extremely well constructed, and proved to be very durable. No material, mechanical, or electrical failures were experienced during more than 80 man-hours of use logged during the evaluation. The manufacturer-specified battery life for all units was exceeded by at least 10%.

The AGA Divetor MK 11 FFM was at first not well received by the Special Forces test subjects because of apprehension experienced with trying out a totally unfamiliar rig. However, once the apprehension was alleviated the rig was extremely well received. It proved it was easy to use and provides one of the most comfortable full face seals available on the market today.

D. General. During testing, the ability of the test subjects to completely and accurately communicate in normal sentences and phrases with other test subjects at a level approaching normal topside speech was noted. There was an initial learning curve for this process similar to that experienced while taking the MRT and became second nature to the test subject in a matter of two to three dives.

The OTS was tested to a maximum depth of 60 FSW. Manufacturer specifications set the depth limit at 200 FSW. Since all seals in the OTS MK 1-D-A and MK 1-D-H systems are o-ring type, no problems are expected in using this unit to the maximum depths for open circuit SCUBA established in the U.S. Army Diving Field Manual FM 20-11-1, or the U.S. Navy Diving Manual.

V. CONCLUSIONS

Intelligibility scores obtained with the OTS systems were well within military standard limits. Subjective evaluations by test subjects indicate an overall, positive, favorable reaction to the equipment.

The range of the OTS systems are considered to be satisfactory to meet foreseeable U.S. Army requirements and no significant human problems, material, or reliability deficiencies were encountered during the evaluation.

The OTS MK 1-D/S, MK 1-DCI, MK 1-S wireless/hardwire underwater communicator, MK 1-D-A and MK 1-D-H with AGA Divetor MK 11 FFM is considered to be a reliable and effective means of communication for the Army SCUBA diver. While a learning curve does exist when using this type of equipment, the OTS is well-engineered and sufficiently automated so that on-the-job training is easily and quickly accomplished.

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APPENDIX A
MANUFACTURERS SPECIFICATIONS

OCEAN TECHNOLOGY SYSTEMS

"TECHNOLOGY IN DEPTH"



MK1-D-A WIRELESS DIVER UNIT

The MK1-D-A Wireless Communicator is primarily designed for free swimming divers or as a back up with umbilical systems. An unlimited number of units can be used together for diver-to-diver or diver-to-surface communications. The MK1-D-A can be used with the AGA full face mask, Widolf full face mask or other suitable full face/½ masks. The unit can be belt, arm, or tank mounted. The MK1-D-A is light weight, self-contained and was designed to be easily adjusted in the field.

FEATURES:

- **Automatic VOX**
Eliminates the need for a push to talk switch.
- **Two Step Squelch**
Helps suppress marine background noise.
- **Easy Battery Access**
No tools necessary to open housing.
- **Small Compact Design**
Easily Belt, Talk or back mounted.
- **One Year Full Warranty**
Parts and labor.
- **Power On Red LED**
- **Large Comfortable Earphone**
Potted, all depth bone conducting type.
- **Mask Microphone Assembly**
Microphone mount to fit your mask and element included with MK1-D-A.
- **Rechargeable Batteries & Charger**
Along with 8 cell holder included with unit.
- **Water Activated**
Will not consume power when out of the water.

Access to the MK1-D-A's battery compartment or to adjust the VOX and/or SQUELCH is a snap. The unit comes standard with an adjustment tool which is kept in the battery compartment. The SQUELCH, VOX, NEGATIVE and POSITIVE terminals are clearly marked to ensure easy field adjustments. The housing can also accommodate spare parts, i.e. o-rings, microphone element. In all, the MK1-D-A is designed to be serviced, in the field, without the need for additional tools.



MK 1 -D-A OPTIONS, ACCESSORIES & SPARE PARTS:

- **BP-1A** — Earphone/microphone assembly with amp connector, (spare part)
- **8CEL** — 8 cell battery holder, (spare part)
- **RB-10A** — Nickel-Cadmium battery pack, (spare part)
- **RC-10A** — Recharger for MK1-D-A, (spare part)
- **ME-150** — Microphone element, 150 ohm
- **MP-1A** — Microphone mount for AGA mask, w/amp connector
- **MP-2W** — Microphone mount for Widolf, $\frac{1}{2}$ mask or 5204 masks, with amp connector
- **PM-1A** — Power microphone/noise cancelling-with earphone/microphone assembly, set up for AGA.
- **SO-1A** — Small O-ring, (spare part)
- **LO-1A** — Large O-ring, (spare part)
- **MK1-S** — Wireless Surface Unit
- **ADT-1A** — Adjustment tool, (spare part)
- **AGA** — AGA full face mask, w/supply hose
- **DF-400** — Widolf full face mask
- **GR-1A** — Gripper ring, (spare part)
- **SPK-1A** — Spare part kit: 2 small O-rings, 1-large O-ring, and gripper ring.

MK 1 -D-A SPECIFICATIONS:

RANGE: Quiet conditions $\frac{1}{4}$ mile, with high background noise, (shrimp, mussels, etc.) 100'

DEPTH: 200 feet

BATTERY LIFE: 6 to 7 hours — 10% duty cycle

TRANSDUCER: Piezo Electric type

FREQUENCY: 31.5 kHz amplitude modulation

SQUELCH: Internal squelch circuitry, two step

ACTIVATION: Water activated

BATTERY TYPE: Rechargeable batteries, (standard) or 8-AA Alkaline batteries, (not included)

VOICE OPERATED TRANSMITTER (VOX): Automatic — adjustable

OPERATING MEDIUM: Salt, fresh or polluted water

STANDARD MICROPHONE ELEMENT: M101 --- 150 ohm element

OPTIONAL MICROPHONE ASSEMBLY: Floodable Piezo Electric noise cancelling w/preamplifier

WEIGHT (In Air): 2 $\frac{1}{4}$ lbs. with rechargeable batteries, 1 $\frac{1}{4}$ lbs. without batteries.

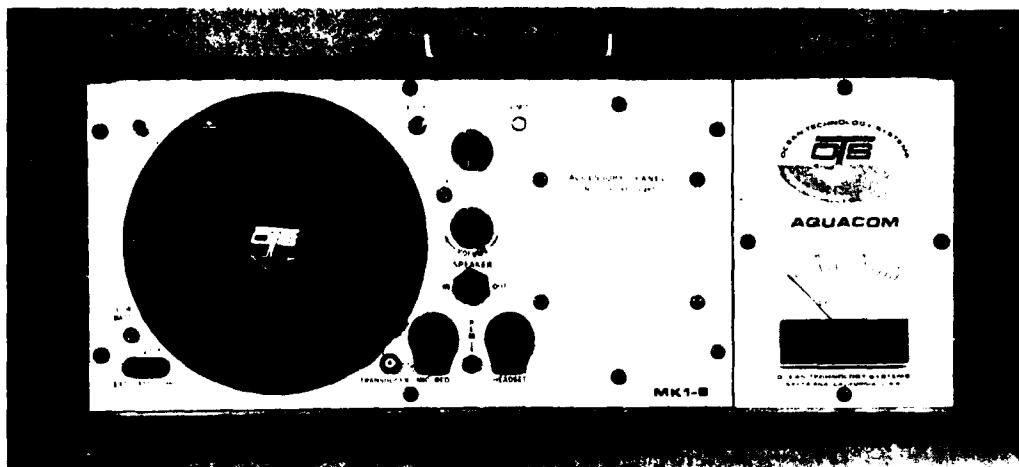
HOUSING DIMENSIONS: Height --- 6", Width — 4 $\frac{3}{4}$ ", Depth — 2"



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OCEAN TECHNOLOGY SYSTEMS

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MK1-S WIRELESS SURFACE UNIT

The MK1-S Wireless Surface Unit is designed to allow wireless, through-water communications from a surface station to wireless divers, between more than one surface stations and from the wireless divers to the surface unit.

Addition of the optional MK1-S-HD Module (see reverse page), would allow you to have a hard line diver on line with the through-water divers. Everyone, wireless and hard wire, could communicate through the MK1-S Surface Unit. The surface tender would have complete control of the interface between the wireless and hard wire divers.

FEATURES:

- **Remote Speaker Jack**
Allows the tender to add an additional speaker
- **Low Battery Indicator**
Flashing red LED provides ample warning before battery needs replacing.
- **Heavy Duty Panel Speaker**
Provides maximum audio power for overriding surrounding noise: pumps, compressors, etc.
- **Record Output**
Permits tender to record diving operations.
- **Squelch**
Adjustment to help eliminate marine biological noise. Conveniently located on the front panel.
- **Transmit LED**
Yellow LED, illuminates when tender transmits.
- **Power On Indicator**
Green LED, lets tender know power is on.
- **Diode Protection**
The external power connection is diode protected against accidental reversed battery connection.
- **Panel Meter**
Provides easy monitoring of battery levels.
- **External Power Connection**
Allows the use of an external battery or other power supplies.
- **Earphone/Microphone Jacks**
In noisy areas, tender can switch to headphones.
- **Accessory Panel**
Allows the addition of the MK1-S-HD, plug in Hard Wire module.
- **Speaker In Or Out**
Permits deactivation of heavy duty panel speaker.
- **Remote Push To Talk Switch**
Allows use of remote transmit/receiver switch, RPTT-25S, (25' remote switch).
- **Splashproof — ABS Plastic Cabinet**
With anodized 1/8" aluminum panel.
- **Transducer & Cable**
Piezo Electric type permanently attached to a 75' cable with a BNC connection to mate with front panel.

MK1-S OPTIONS & ACCESSORIES:

RB-12 — 12 Volt rechargeable, maintenance free, battery complete with wire harness.

RC-13 — Recharger for RB-12 rechargeable battery.

RPTT-25S — Push to talk, remote 25' switch. Allows tender to operate MK1-S from a remote location. Must be used with a headset with boom microphone, not included.

THB-1 — Deluxe Telex headset with boom microphone.

TC-75 — Transducer cable, 75' with BNC plug.

TC-100 — Transducer cable, 100' with BNC plug.

HHM-25 — Hand held microphone with push to talk switch.

ME-8 — Microphone element, 8 ohm.

ME-150 — Microphone element, 150 ohm.

CABLE — Two or four communication cable.

AGA — AGA full face mask.

WIDOLF — Widolf full face mask

MM-2 — Marsh Marine underwater connectors, male & female.

E/O-2 — E/O Underwater connectors, male & female.

MK1-D — Wireless diver communications, set up for AGA or Widolf.

MK1-S SPECIFICATIONS:

RANGE: Quiet conditions 1/4 mile, with high background noise, (shrimps, mussels, etc.) 100' range.

FREQUENCY: 31.5 kHz amplitude modulation.

BATTERY LIFE: 40 hours — 20% duty cycle, (rechargeable battery — RB-12).

BATTERY TYPE: Two 6 volt lantern batteries, recommended batteries — Eveready Heavy Duty Alkaline #528 or Duracell Heavy Duty Alkaline battery #1D9150 or external 12 volt source — optional 12 volt rechargeable batteries (RB-12), and Charger (RC-13).

HOUSING: ABS plastic, chemically bonded, reinforced with heavy duty ribs and stainless steel hardware.

FRONT PANEL: 1/8" aluminum, chemically treated and coated with a tough, durable urethane finish to withstand the marine environment.

SQUELCH: Manually operated from the front panel.

TRANSDUCER: Piezo Electric type, complete with 75' transducer cable and BNC plug.

INDICATORS: Low battery (Red), Transmit (Yellow), Power On (Green), all LED type.

HOUSING DIMENSIONS: Height 6-5/8" (16.8 cm), Width 16-3/8" (41.6 cm), Depth 8-3/8" (21.3 cm), Weight 12-1/2 lbs., in shipping carton 15 lbs.

Specifications subject to change without notice.

MK1-S-HD

WIRE DIVER

PUSH TO



TALK



VOLUME
TO DIVER



VOLUME
TO TENDER



CROSS TALK
SCUBA TO WIRE



WIRE TO SCUBA
MICROPHONE



WIRE
BOTH SCUBA



EARPHONE

Allows a Hard Wire diver or bell to be on line with the through-water divers. Tender has control of communications between all divers, hardwire and wireless.

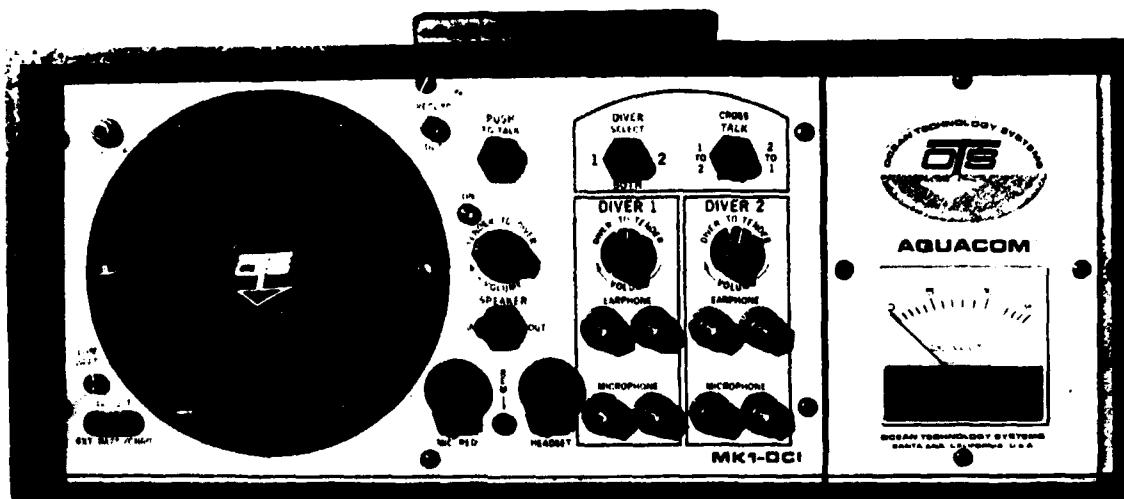


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OCEAN TECHNOLOGY SYSTEMS

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MK1-DCI TWO DIVER AIR RADIO

The Model MK1-DCI is a compact, self-contained Two Diver Air Radio providing two wire communications between the operator and one or two divers. The MK1-DCI also has four wire (round-robin) capabilities using any standard four wire cable. Special shielded cable is unnecessary.

The MK1-DCI is competitively priced and provides exceptionally clear communications between divers and tender. Additionally, the MK1-DCI comes standard with many features normally considered options.

FEATURES:

- **Four Wire Capability**
Use any four wire cable, does not need shielded cable.
- **Low Battery Indicator**
Flashing red LED provides ample warning before battery needs replacing.
- **Record Output**
Permits tender to record diving operations.
- **External Speaker Jack**
Allows the tender to add an additional speaker.
- **Panel Meter**
Provides easy monitoring of battery levels.
- **Separate Volume Controls For Tender And Divers**
Eliminates distortion from overloading earphones and allows separate adjustment to divers earphones.
- **Speaker Can Be Deactivated Easily**
Via on/off switch conveniently located on front panel.
- **Heavy Duty Panel Speaker**
Provides maximum audio power for overriding surrounding noise (pumps, compressors, helicopters).
- **External Power Connection**
Allows the use of an external battery or other power supplies.
- **Diode Protection**
The external power connection is diode protected against accidental reversed battery connection.
- **Heavy Duty Switches**
Ensures long lasting performance in the marine environment.
- **Splashproof — ABS Plastic Cabinet**
With anodized 1/8" aluminum front panel.
- **Power On Indicator — Green LED**
Lets tender visually see radio is on.
- **Earphone/Microphone Jacks**
In noisy areas tender can switch to headphones.

SPECIAL NOTATION:

The MK1-DCI two diver air radio will provide maximum performance when operated in the four wire mode. By wiring the microphone/earphone separately, intelligibility is greatly enhanced while eliminating the need to use a push to talk switch.

All divers and tender are in constant communications similar to a telephone conference hook up. For further information regarding four wire communications, contact us or your local Ocean Technology Systems dealer.

MK1 -DCI OPTIONS & ACCESSORIES:

- **RB-12** — 12 Volt rechargeable, maintenance free, battery complete with wire harness.
- **RC-13** — Recharger for RB-12 rechargeable battery.
- **RPTT-25** — Push to talk, remote 25' switch. Allows operation of MK1-DCI from a remote location. Must use headset with boom microphone, not included.
- **THB-1** — Deluxe Telex headset with boom microphone.
- **HHM-25** — Hand held microphone with push to talk switch.
- **E/O-2** — E/O underwater connector, male & female, each comes bare wire to connector.
- **MM-2** — Marsh Marine underwater connector, male & female, connector to bare wire.
- **EP-1** — Earphone, potted. Lollipop type. Element to bare wire.
- **ME-8** — 8 ohm microphone element.
- **ME-150** — 150 ohm microphone element.
- **EM-2** — Earphone/microphone assembly with amp connections.
- **CABLE** — Communication cable, four or two Wire, with or without u/w connections.

MK1 -DCI SPECIFICATIONS:

BATTERY LIFE: 20 Hours continuous use, (with Gell cell optional battery).

BATTERY TYPE: Two 6 Volt lantern batteries, recommended batteries — Eveready Heavy Duty Alkaline #528 or Duracell Heavy Duty Alkaline battery #1D9150 or external 12 Volt source — optional 12 Volt rechargeable batteries (RB-12 and charger RC-13).

POWER OUTPUT: 8 Watts

FREQUENCY RESPONSE: 600 to 12,000 Hz

CABINET MATERIAL: ABS plastic, chemically bonded, reinforced with heavy duty ribs and stainless steel hardware.

FRONT PANEL: 1/8" Aluminum, chemically treated and coated with a tough, durable urethane finish to withstand the marine environment.

SIZE: HEIGHT: 6-5/8" inches (16.8 cm)

WIDTH: 16-3/8 inches (41.6 cm)

DEPTH: 8-3/8 inches (21.3 cm)

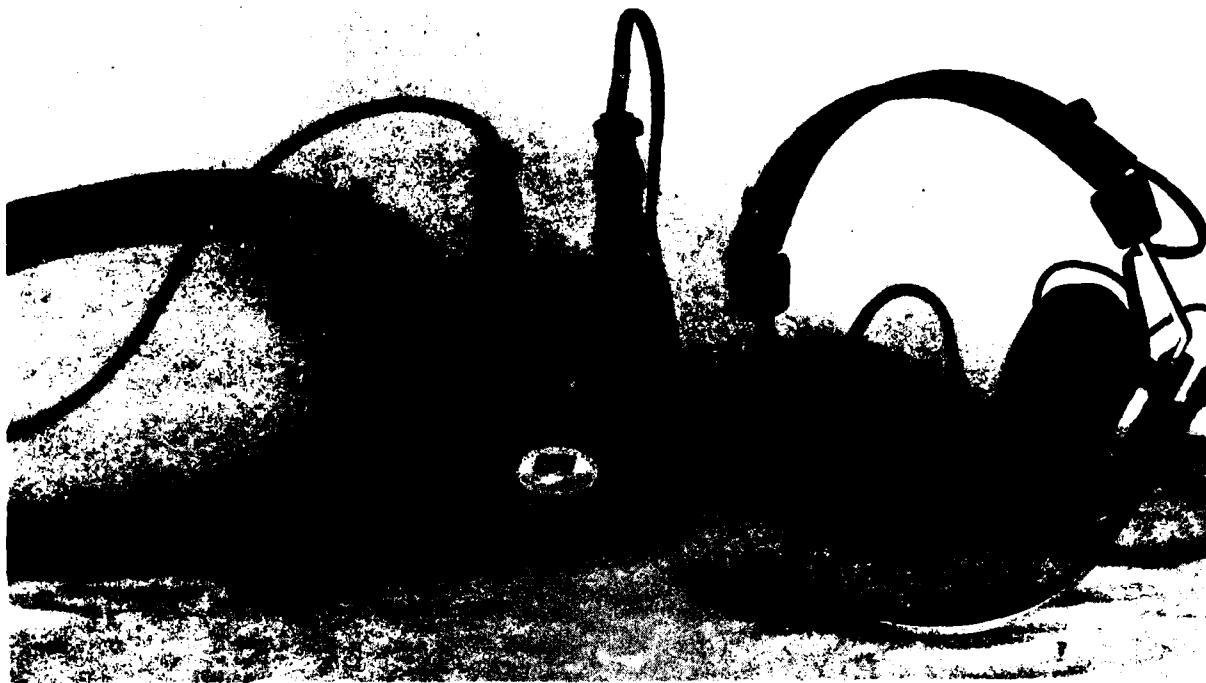
WEIGHT: 12 lbs.; in shipping carton, 14-1/2 lbs.



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"TECHNOLOGY IN DEPTH"



MK1-D/S WIRELESS PORTABLE SURFACE UNIT

The MK1-D/S was designed as a portable wireless surface station and a wireless diver unit. Custom applications are available, such as mounting the unit in a submersible (where the transducer must be installed outside the vehicle), on an underwater video system (extra long earphone/microphone assemblies are necessary) or mounting the transducer to a helmet, etc.

The MK1-D/S is made with the highest quality components assuring the most reliable through-water communicator on the market. The housing is constructed of high impact, glass filled, injection molded polycarbonate. High grade stainless steel Nielsen latches with black passivate treatment are standard. No tools are required to gain access to the battery compartment or the adjusting controls.

The MK1-D/S is easily converted to a divers communicator by the addition of the surface accessory kit, (CDK-2). The tender can record diving operations by the addition of either a RCA-2C or RMJ-2C adapter. In all, the MK1-D/S portable surface unit will meet all your special requirements assuring you the utmost in reliability and performance.

FEATURES:

- **Automatic Vox**
eliminates the need for a push to talk switch
- **Two Step Squelch**
helps suppress marine background noise
- **Easy Battery Access**
no tools necessary to open housing
- **Small Compact Design**
easily belt, tank or back mounted
- **One Year Full Warranty**
parts and labor

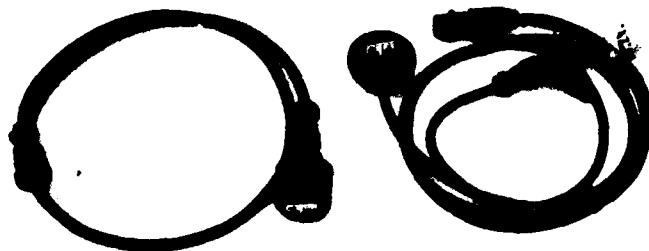
- **Deluxe Telex Headset (THB-1)**
includes boom Mic. & Amp connector
- **50 Ft. Transducer Cable**
transducer with Amp connector
- **Rechargeable Battery Pack**
ten NiCad batteries, RB-10A
- **Recharger, RC-10A**
- **Adjustment Tool**
conveniently located in the inside assuring quick and easy field adjustments

The MK1-D/S wireless unit, when utilized as a surface station, allows communications, surface-to-diver, diver-to-surface or surface-to-surface, through-water. Because of its compact design, the MK1-D/S is ideal for use in small boats and other confined areas.



MK1-D/S OPTIONS, ACCESSORIES & SPARE PARTS:

- AGA, Widolf or half masks
- CDK-2 - surface accessory kit, allows MK1-D/S to be utilized as a diver unit
- TC75C - transducer cable, 75 ft. with Amp connection
- TC100C - transducer cable, 100 ft. with Amp connection
- RMJ-2C - record patch cord, mini plug
- RCA-2C - record patch cord, RCA plug
- 8CEL - 8 cell battery holder.
- SPK-1A - spare parts o-ring kit
- Custom transducers or cable per quote



CDK-2

MK1-D/S SPECIFICATIONS:

RANGE: quiet conditions $\frac{1}{4}$ mile, with high background noise (shrimp, mussels, etc.) 100 ft.

DEPTH: 200 feet

BATTERY LIFE: 6 to 7 hours - 10% duty cycle

TRANSDUCER: piezoelectric type

FREQUENCY: 31.5 KHz amplitude modulation

SQUELCH: internal squelch circuitry, two step

ACTIVATION: water

BATTERY TYPE: rechargeable batteries (standard), or 8-AA Alkaline batteries (not included)

VOICE OPERATED TRANSMITTER (VOX): automatic-adjustable

OPERATING MEDIUM: salt, fresh and polluted water

WEIGHT (in air): 2 lbs. with rechargeable batteries, $1\frac{1}{4}$ lbs. w/o battery

WEIGHT - 50 ft. Transducer cable: $1\frac{1}{2}$ lbs.

WEIGHT - TELEX HEADSET: 1 lb.

HOUSING DIMENSIONS: height: 5 $\frac{1}{2}$ "

width: 4 $\frac{1}{2}$ "

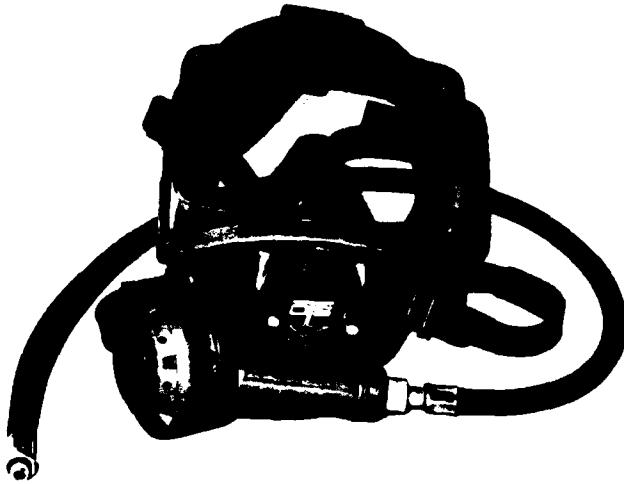
depth: 2"



OCEAN TECHNOLOGY SYSTEMS
2610 Croddy Way, Unit H, Santa Ana, CA 92704 714/754-7848

OCEAN TECHNOLOGY SYSTEMS

"TECHNOLOGY IN DEPTH"



The AGA MK-II is U.S. Navy approved and has been successfully tested to a depth in excess of 2000 feet by Duke University.

The MK-II Full Face Mask is easily adapted for most any type of communications, i.e., wireless or hard wire.

The AGA MK-II Full Face Mask with breathing valve is of the demand type which only releases the air on inhalation. The breathing valve is closely fitted to the face mask with a bayonet coupling. In this way the parts form a compact unit.

The MK-II operates with positive pressure which prevents water from entering the face mask which could otherwise occur, e.g., due to fitting leakage. The positive pressure is automatically turned on as soon as the user starts breathing from the apparatus. In this way, there is no risk of forgetting to turn on the positive pressure or of it being accidentally turned off.



MK-II AGA FULL FACE MASK

FEATURES:

■ Automatic Defogging

Air flow enters the mask via 2 defogger ports assuring constant defogging while simultaneously cooling the divers face.

■ Automatic Safety Pressure

Positive pressure is automatically turned on as soon as the user starts breathing — preventing water leakage.

■ Low Breathing Resistance

A fully balanced high volume second-stage regulator provides extremely low exhalation and inhalation resistance even under extreme work loads and deep depths.

■ Extremely Low CO₂

CO₂ buildup is virtually eliminated by the use of a small oral-nasal cavity and separate inhalation and exhalation ports.

■ Light Weight/Easy To Use

Donning and doffing of the mask is achieved easily due to the light weight and quick adjustable release buckles.

■ Communications

The MK-II AGA full face mask can be readily adapted for any type of communications, i.e., O.T.S. Wireless communications (MK1-D-A) or Hard wire communications (MK1-DCI) by means of the addition of the MP-1A mask mounting plate with noise cancelling microphone and the BP-1A Earphone/Microphone assembly.

■ Low Profile/High-Impact Visor

Excellent field of view coupled with high-impact resistant material equals longevity.

■ HAZ-MAT Tested

Field proven in polluted areas keeping the divers face clean & dry. Constructed of rugged materials resistant to temperature, corrosion, ultraviolet radiation, and high impact.

■ Tabs For Eye Glasses

Wire rimmed glasses can be easily installed.

THE BREATHING VALVE:

The breathing valve is of the demand type i.e., air is only supplied during an inhalation. The breathing valve is balanced in order to ensure the same extremely low breathing resistance irrespective of variations in the secondary pressure. The valve is designed to give a slight positive pressure of approximately 200 Ps (20mm water column) in the mask. The positive pressure is turned on automatically when the user takes his first inhalation in the mask. This ensures that there is no way of forgetting to turn on the positive pressure or that it could become accidentally turned off.

In order to make the breathing protection safe in all environments and under all working conditions the breathing valve has been designed to supply at least 3001/min or air without any negative pressure arising in the mask.

The breathing valve works in the following way, see exploded view.

During inhalation the pressure in the face mask and the breathing valve (1) decrease in relation to the pressure outside the exhalation diaphragm. The diaphragm assembly (3) also aided by positive pressure spring (2) will thereby push inwards on the lever fork (4). The lever fork (4) will be pressed back and the lever will pivot against the lever support pulling the rod (5) forward and with it the lifting spindle (6) drawing it away from the valve seat (7) in the nipple. Breathing air will now flow into the valve and mask via the channel (8) flushing the visor and on into the inner mask.

As soon as the inhalation has been terminated the lever fork (4) will return to its original position and the lifting spindle (7) with valve cone will close the valve inlet with the aid of the sealing spring (9). The sealing spring (9) is adjusted by nut (10). During exhalation the air will be expelled to ambient through channel (11) and the exhalation valve (12). The exhalation diaphragm (13) will lift and exhaled air will escape through the slot (14) in the diaphragm cover. The breathing valve is also designed as a safety valve for the regulator. Should the secondary pressure increase to between 1.2-1.6 MPa (12-16bar) the pressure that builds up in this way will push on the balancing diaphragm and the relief valve piston (17). The force of the relief valve spring (15) will be overcome and the piston (17) will be pushed backwards to press against the lever rod (5) which will open the valve and let the air free flow. This will continue until the pressure drops below approximately 1 MPa (10bar).

SPECIFICATIONS:

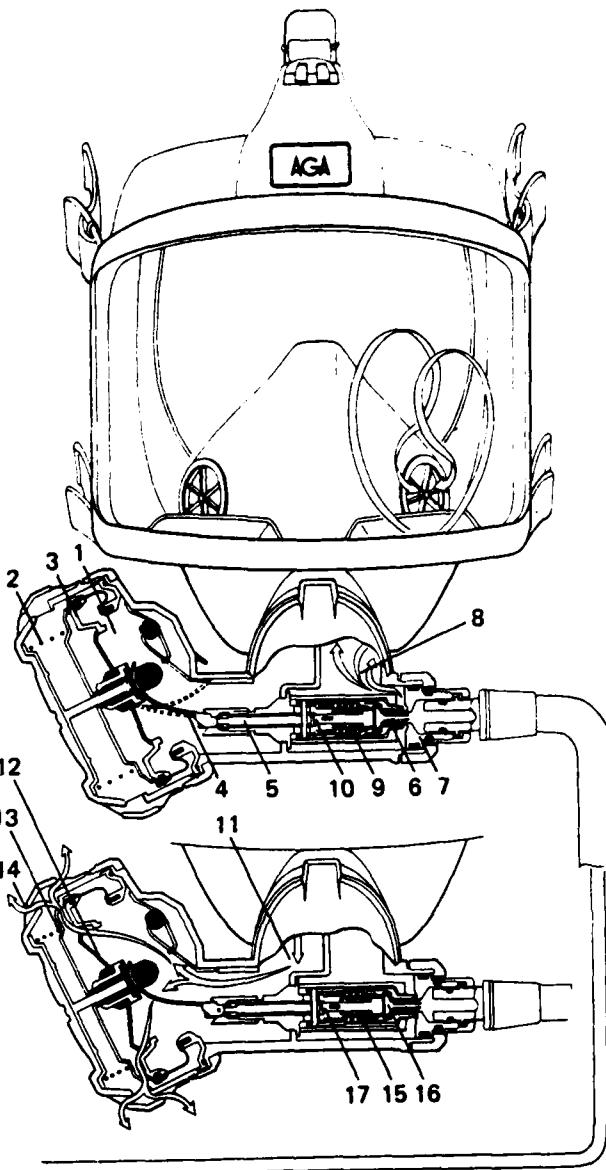
MK-II MASK: Visor, connector and breathing valve are made of a special nylon plastic. Mask and head strap are made of natural rubber and the buckles are a high grade stainless steel.

SIZE: WIDTH: 6-7/8"

HEIGHT: 10" (nominal)

DEPTH: 5" (nominal)

WEIGHT: 2 lbs. including supply hose, 4 lbs. shipping.



APPENDIX B

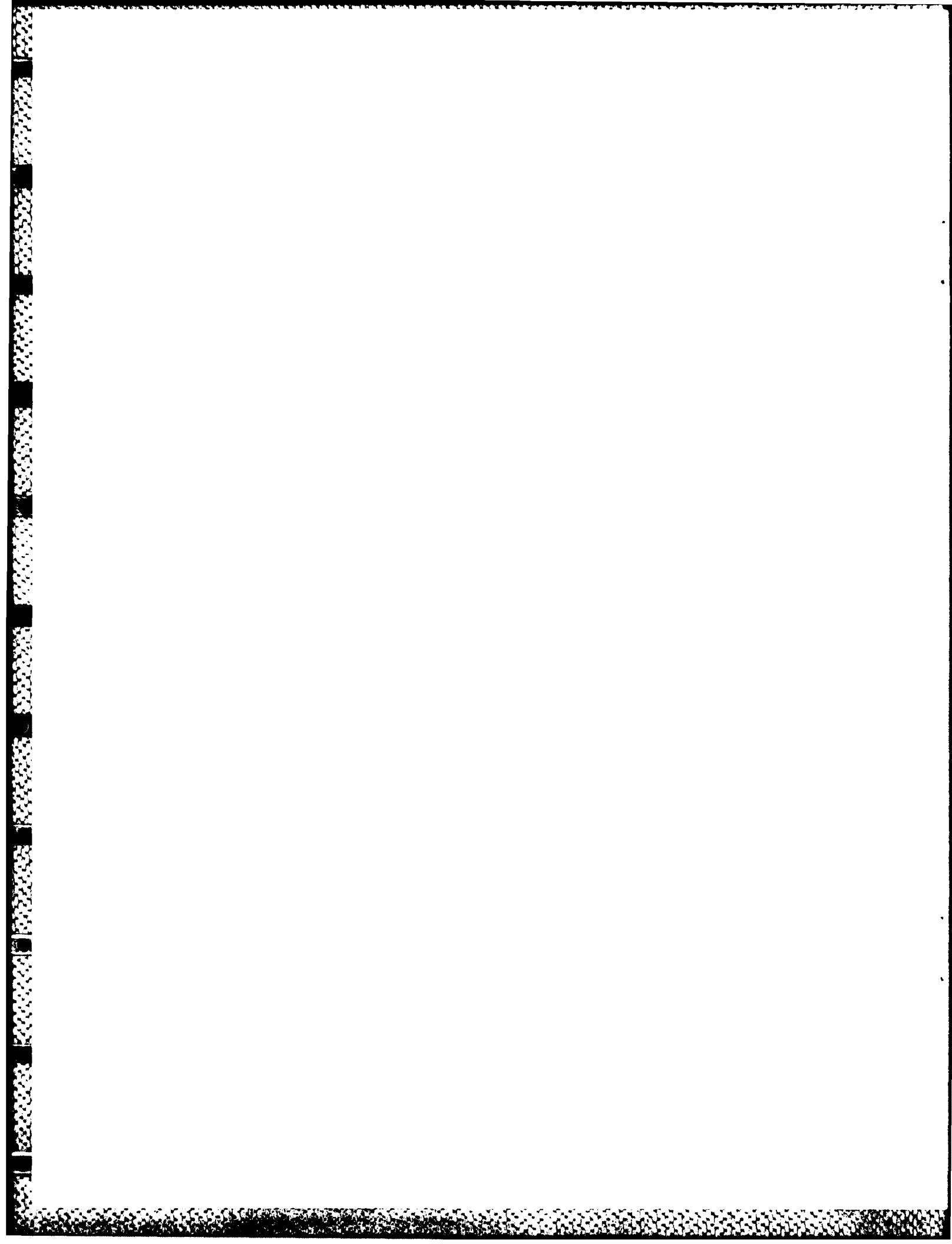
B1 MRT READING WORD LIST SAMPLE

B2 MRT RESPONSE WORD LIST SAMPLE

RED

READING LIST 2

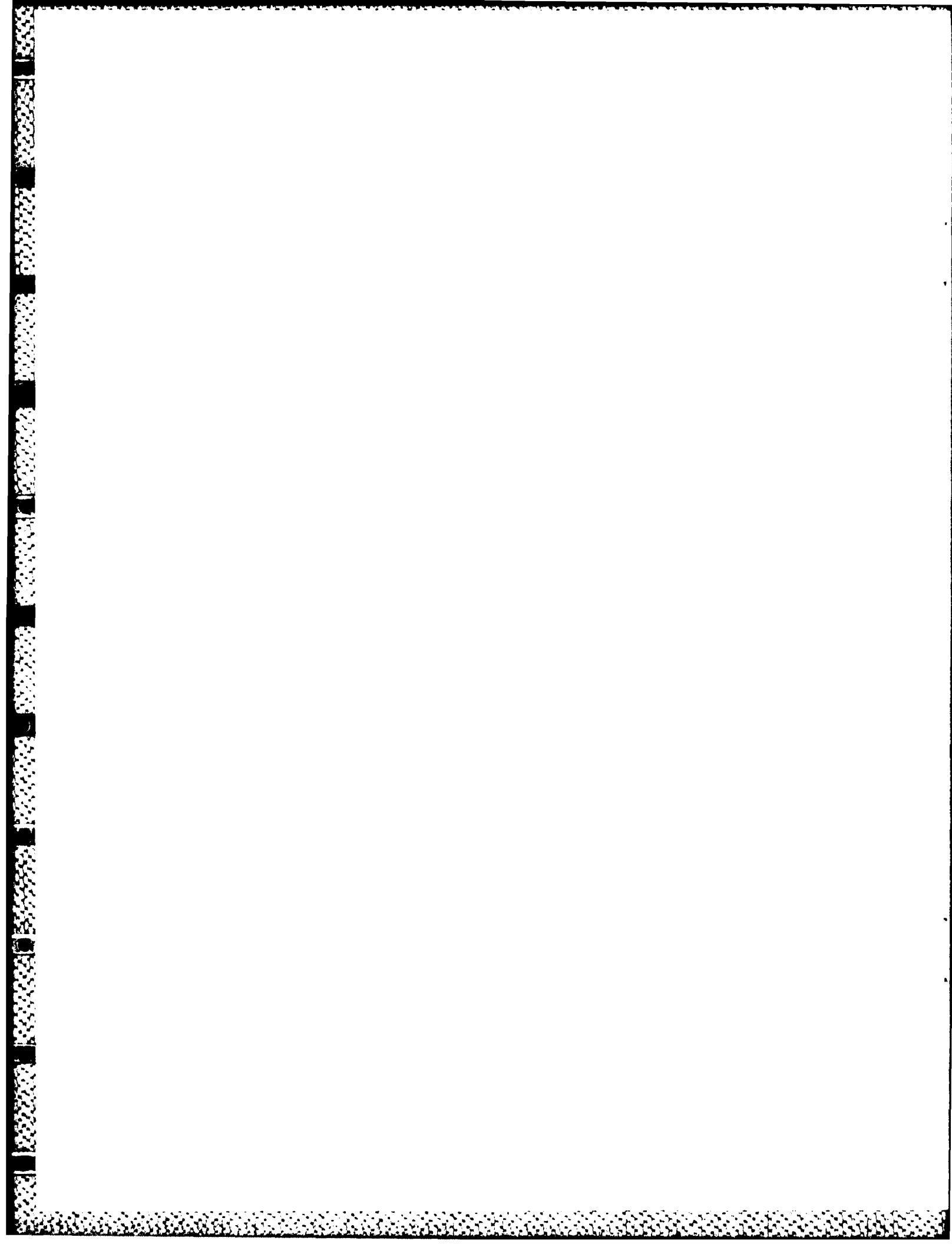
| | A | B | C | D | E | | A | B | C | D | |
|----|--------|--------|---------|--------|-------|----|-------|-------|-------|-------|------|
| 1 | bat | batch | bash | bass | badge | 26 | led | shed | red | wed | fed |
| 2 | laws | long | log | lodge | lob | 27 | sold | cold | hold | told | gold |
| 3 | wig | with | wit | witch | wick | 28 | dig | wig | big | rig | pig |
| 4 | dumb | dub | doth | duff | dove | 29 | kick | chick | thick | pick | sick |
| 5 | cuff | cub | cut | cup | cud | 30 | fin | tin | shin | kin | this |
| 6 | dig | din | dic | dim | dill | 31 | bark | dark | mark | lark | park |
| 7 | dun | dud | dung | dub | dug | 32 | gale | pale | tale | bale | male |
| 8 | fill | fig | fin | fizz | fib | 33 | peel | feel | eel | heel | keel |
| 9 | leave | liege | leach | leash | lead | 34 | will | hill | kill | till | bill |
| 10 | toss | taj | tong | talks | tog | 35 | feel | reel | seal | zeal | veal |
| 11 | lash | lack | lass | laugh | lath | 36 | shame | game | came | same | tame |
| 12 | mat | mad | math | man | mass | 37 | ten | pen | den | hen | ther |
| 13 | beige | base | bayed | bathe | bays | 38 | pin | sin | tin | win | fin |
| 14 | pass | path | pack | pad | pat | 39 | thin | tin | chin | shin | gin |
| 15 | peak | peas | peal | peace | peat | 40 | thee | dee | lee | knee | zee |
| 16 | pick | pit | pip | pig | pitch | 41 | rent | bent | went | dent | ten |
| 17 | pup | puff | pub | puck | pus | 42 | hip | rip | tip | dip | lip |
| 18 | hath | hash | half | have | has | 43 | top | hop | pop | cop | shop |
| 19 | we're | weal | weave | weed | wean | 44 | yore | gore | wore | lore | roar |
| 20 | sad | sat | sag | sack | sap | 45 | vie | thy | fie | thigh | high |
| 21 | sheen | sheave | sheathe | sheath | sheaf | 46 | zip | lip | nip | gyp | sly |
| 22 | sing | sip | sin | sit | sick | 47 | nest | best | vest | rest | west |
| 23 | sud | sum | sub | sun | sung | 48 | bust | just | rust | gust | dust |
| 24 | tab | tan | tam | tang | tap | 49 | mat | vat | that | fat | rat |
| 25 | teethe | tear | tease | teel | teeth | 50 | way | may | gay | they | nay |



Y ELL OW

READING LIST 5

| | A | B | C | D | E | | A | B | C | D | E |
|---|--------|--------|---------|--------|-------|----|-------|-------|-------|-------|------|
| 1 | bat | batch | bash | bass | badge | 26 | led | shed | red | wed | fed |
| 2 | laws | long | log | lodge | lob | 27 | sold | cold | hold | told | gold |
| 3 | wig | with | wit | witch | wick | 28 | dig | wig | big | rig | pig |
| 4 | dumb | dub | doth | duff | dove | 29 | kick | chick | thick | pick | sick |
| 5 | cuff | cub | cut | cup | cud | 30 | fin | tin | shin | kin | thin |
| 6 | dig | din | dic | dim | dill | 31 | bark | dark | mark | lark | park |
| 7 | dun | dud | dung | dub | dug | 32 | gale | pale | tale | bale | male |
| 8 | fill | fig | fin | fizz | fib | 33 | peel | feel | eel | heel | keel |
| 9 | leave | liege | leach | leash | lead | 34 | will | hill | kill | till | bill |
| 0 | toss | taj | tong | talks | tog | 35 | feel | reel | seal | zeal | veal |
| 1 | lash | lack | lass | laugh | lath | 36 | shame | game | came | same | tame |
| 2 | mat | mad | math | man | mass | 37 | ten | pen | den | hen | then |
| 3 | beige | base | bayed | bathe | bays | 38 | pin | sin | tin | win | fin |
| 4 | pass | path | pack | pad | pat | 39 | thin | tin | chin | shin | gin |
| 5 | peak | peas | peal | peace | peat | 40 | thee | dee | lee | knee | zee |
| 6 | pick | pit | pip | pig | pitch | 41 | rent | bent | went | dent | tent |
| 7 | pup | puff | pub | puck | pus | 42 | hip | rip | tip | dip | lip |
| 8 | hath | hash | half | have | has | 43 | top | hop | pop | cop | shop |
| 9 | we're | weal | weave | weed | wean | 44 | yore | gore | wore | lore | roar |
| 0 | sad | sat | sag | sack | sap | 45 | vie | thy | fie | thigh | high |
| 1 | sheen | sheave | sheathe | sheath | sheaf | 46 | zip | lip | nip | gyp | slip |
| 2 | sing | sip | sin | sit | sick | 47 | nest | best | vest | rest | west |
| 3 | sud | sum | sub | sun | sung | 48 | bust | just | rust | gust | dust |
| 4 | tab | tan | tam | tang | tap | 49 | mat | vat | that | fat | rat |
| 5 | teethe | tear | tease | teel | teeth | 50 | way | may | gay | they | nay |



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LOCATION: ORIN BA DATE: 1-1-85

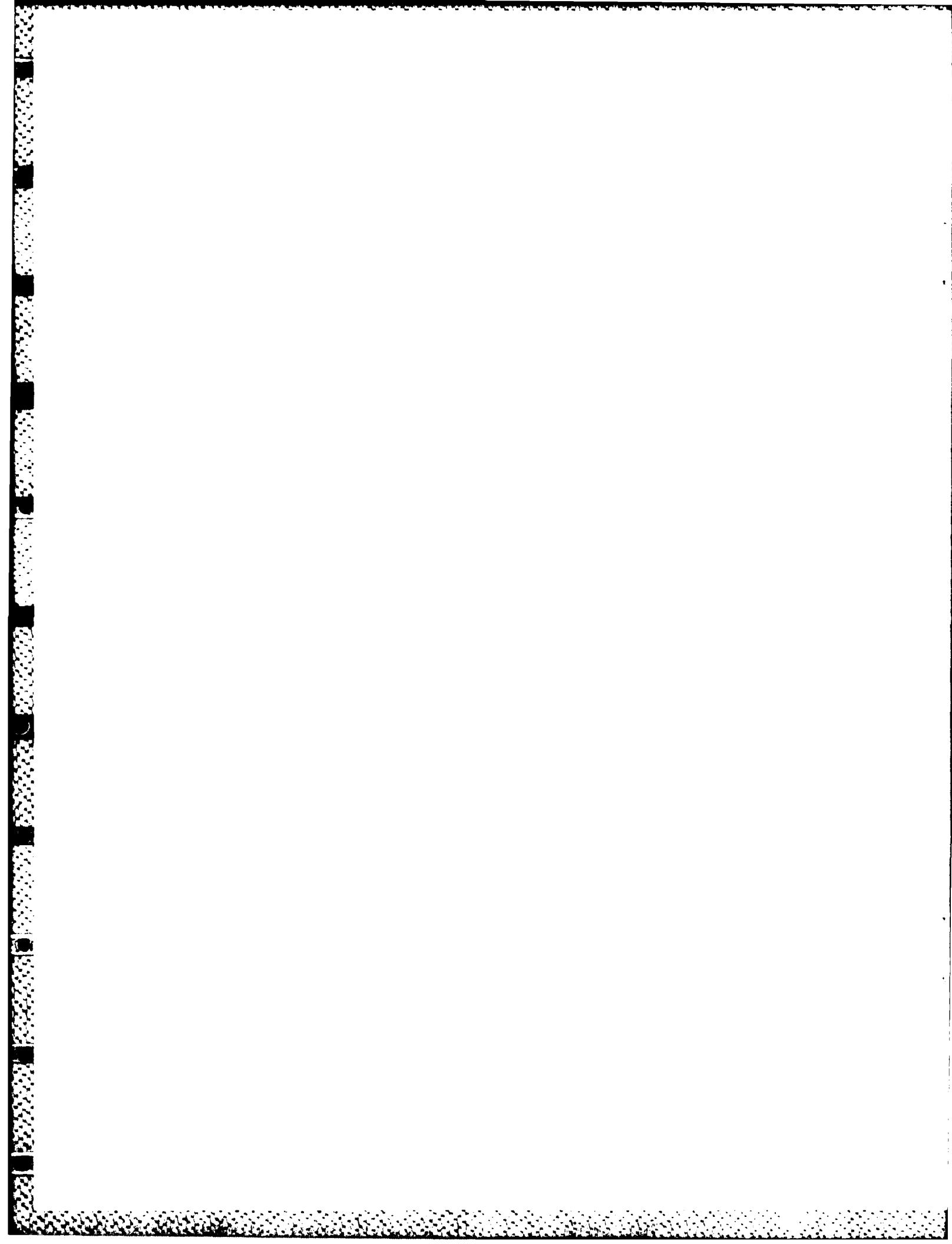
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LEAVING TO AGA

RESPONSE SHEET 6

AGA

| | A | B | C | D | E | | A | B | C | D | E |
|----|--------|--------|---------|--------|-------|----|-------|-------|-------|-------|------|
| 1 | bat | batch | bash | bass | badge | 26 | led | shed | red | wed | fed |
| 2 | laws | long | log | lodge | lob | 27 | sold | cold | hold | told | gold |
| 3 | wig | with | wig | witch | wick | 28 | dig | wig | big | rig | pig |
| 4 | dumb | dub | doth | duff | slove | 29 | kick | chick | thick | pick | sick |
| 5 | cuff | cub | cut | cup | cud | 30 | fin | tin | shin | kin | thin |
| 6 | dig | din | did | dim | dill | 31 | bark | dark | mark | lark | park |
| 7 | dun | dud | dung | dub | dug | 32 | gale | pale | tale | bale | male |
| 8 | fill | fig | fin | fizz | fib | 33 | peel | feel | eel | heel | keel |
| 9 | leave | liege | leach | leash | lead | 34 | will | hill | kill | till | bill |
| 10 | toss | taj | tong | talks | tog | 35 | feel | feet | seal | zeal | veal |
| 11 | lash | lack | lass | laugh | lath | 36 | shame | game | came | same | name |
| 12 | mat | mad | math | man | mass | 37 | ten | pen | den | hen | then |
| 13 | beige | base | bayed | bathe | bays | 38 | pin | sin | tin | win | fin |
| 14 | pass | path | pack | pad | pat | 39 | thin | tin | chin | shin | gin |
| 15 | peak | peas | peal | peace | peat | 40 | thee | dee | lee | knee | zee |
| 16 | pick | pit | pip | pig | pitch | 41 | rent | bent | went | dent | tent |
| 17 | pup | puff | pub | puck | pus | 42 | hip | rip | tip | dip | lip |
| 18 | hath | hash | half | have | has | 43 | top | hop | pop | cop | shop |
| 19 | we're | weal | weave | weed | wean | 44 | yore | gore | wore | lore | roar |
| 20 | sad | sat | sag | sack | sap | 45 | vie | thy | fie | thigh | high |
| 21 | sheen | sheave | sheathe | sheath | sheaf | 46 | zip | lip | nip | gyp | slip |
| 22 | sing | sip | sin | sit | sick | 47 | nest | best | vest | rest | west |
| 23 | sud | sum | sub | sun | sung | 48 | bust | just | rust | gust | dust |
| 24 | tab | tan | tam | tang | tap | 49 | mat | vat | that | fat | rat |
| 25 | teethe | tear | tease | teel | teeth | 50 | way | may | gay | they | hay |



APPENDIX C
COMMUNICATOR EVALUATION FORM

COMMUNICATION EVALUATION FORM

System Used:

Date:

Depth

Total Time of Dive:

Pre-Dive:

Donning Easy Slight Difficulty Difficult

Check Good Marginal Poor

Remarks: _____

During Dive:

In Water Check Good Marginal Poor

Legibility Good Marginal Poor

Comfort Good Marginal Poor

Distance between divers:

Remarks: _____

Post-Dive:

Doffing Easy Slight Difficulty Difficult

Remarks: _____

Maintenance:

a. Directions: Adequate Inadequate

b. Procedures: Simple Complex

c. Tools Req: No Few Many or Special

Remarks: _____

Diver's Personal Opinion:

Signature

END

FILMED

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